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*EDITED BY CHAS. COOPER AND J. FOSTER PETREE.*

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# LOOK INTO BOILER EFFICIENCY

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# RAILWAY BRIDGE WITH 100-FT. ALUMINIUM SPAN.

For a number of years the Aluminum Company of America have desired to test, on a practical scale, the suitability of aluminium alloy as a constructional material for railway bridges. The considerations involved in this matter are not only those of cost; as the modulus of elasticity of aluminium is about one-third that of steel, aluminium structures are necessarily more flexible than those built from the latter material. The coefficient of expansion of aluminium is also about twice that of steel, the value for aluminium alloys ranging from 22 to $27 \times 10^{-6}$ per degree C., as compared with 11 to $15 \times 10^{-6}$ per deg. C. for steel. This difference may introduce special design problems. Although it does not seem likely that aluminium will replace steel as a general structural material, some arguments may be put forward for its use in special cases. Its lightness may make it particularly suitable for lifting spans of bridges, and this quality may also simplify erection operations. By proper treatment it may also be made highly resistant to corrosion, making it a convenient material for exposed situations. The Aluminum Company does not contend that aluminium structures can compete in cost with those built of steel, although the price of aluminium has fallen during recent years, but it is naturally desirous to extend the field of application of the metal. In suitable cases, the increased cost may be offset by attendant advantages.

An opportunity to make a full-scale practical test of aluminium alloy as a constructional material for railway bridges arose in connection with the reconstruction of the Grasse River Bridge, near Massena, in the northern part of the State of New York. This bridge carries a single-line spur railway, about two miles long, which connects the Massena plant of the Aluminum Company with both the New York Central and Canadian National Railways. The original bridge, which was built in 1897, consisted of two plate-girder spans, 50 ft. long and four Warren girder spans 100 ft. long; it can be seen in the foreground in Fig. 1, on this page. Owing to the increased weight both of the locomotives and loaded wagons it became necessary to replace the original bridge by a stronger structure, and the opportunity was taken to incorporate an aluminium span in the new bridge, which can be seen behind the old structure in Fig. 1. The reason the new bridge lies at a higher level than the old is that the general reconstruction work, undertaken in connection with increase in the capacity of the line, included the enlargement of a marshalling yard, and the new layout enabled the railway grades to be improved by moving the position of the bridge 63 ft. to the east and raising the level by 20 ft.

The new bridge consists of seven plate-girder spans, one 90 ft. long, four 100 ft. long, and two 75 ft. long. The co-operation of the railway company was secured in the decision to construct one of the 100-ft. spans entirely of aluminium alloy. The situation of the bridge in the neighbourhood of the Massena works is particularly favourable in enabling the Aluminum Company to observe the behaviour of the aluminium span in relation to the neighbouring steel spans. The bridge is used only for freight service, operated by three 600-h.p. Diesel-electric locomotives, but the nature of the traffic will enable test runs to be made by heavy steam locomotives. The aluminium span, the position of which is clearly indicated by its lighter colour in Fig. 1, weighs only 53,000 lb., as compared with 128,000 lb. for the neighbouring steel span of the same length. The relative costs of the two spans have not been furnished, but in the particular circumstances of this experimental installation the matter is of secondary importance.

In an article in the December, 1946, issue of *Civil Engineering*, the monthly journal of the American Society of Civil Engineers, Mr. Shortridge Hardesty, M.A.S.C.E., and Mr. J. M. Garrelts, M.A.S.C.E., point out that, although the Grasse River Bridge incorporates the first example of an all-aluminium bridge span, aluminium alloy was used as long ago as 1933 for bridge decking. In that year, the steel and wood floor system of the Smithfield-street Bridge, Pittsburg, was replaced by an aluminium-alloy deck. As the weight was only half that of the original floor, the old steel trusses and masonry foundations were made safe for heavy modern traffic. Although the aluminium-alloy deck is exposed to a corrosive industrial atmosphere, it is still satisfactory after 14 years of service. Studies of the use of the material have been made in connection with various lifting spans and other bridge features in which dead weight was an important factor, and although these have not resulted in practical applications they have shown that aluminium alloy has strong claims to consideration in special cases.

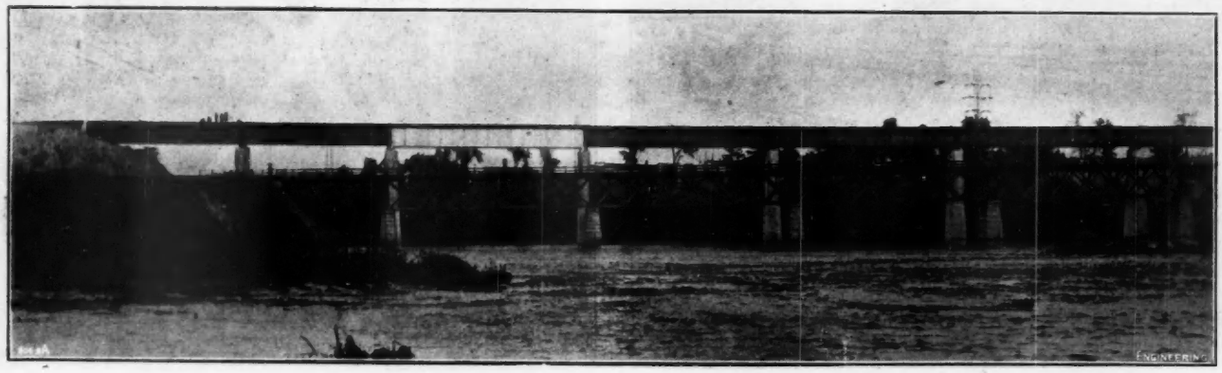

FIG. 1. OLD AND NEW BRIDGES; LOOKING EAST.

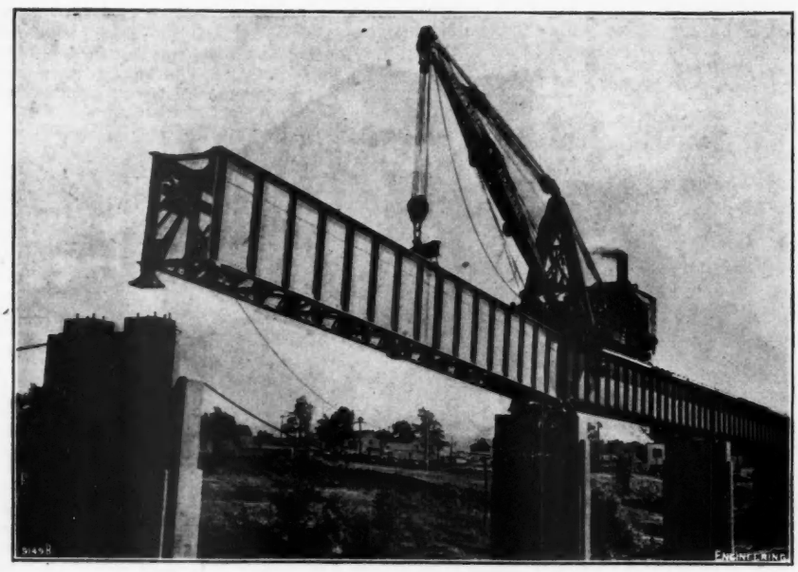

FIG. 2. ALUMINIUM SPAN BEING LIFTED INTO POSITION.

The Grasse River span is constructed of an alloy known as 14S-T. This material, which has been in use for more than 25 years, combines high strength with good resistance to atmospheric corrosion. It has been used for heavy-duty forgings in excavators and other machines, and has found considerable application in the manufacture of aeroplane parts. It was also used for the floor system of the standard pontoon-bridge units of the United States Army. The material contains 4·4 per cent. of copper; 0·8 per cent. of silicon; 0·8 per cent. of manganese; and 0·4 per cent. of magnesium. Typical mechanical properties are: ultimate tensile strength, 70,000 lb. per square inch; yield strength (2 per cent. set), 60,000 lb. per square inch; elongation in 2 in. ($\frac{1}{2}$ in. diameter specimen), 13 per cent.; Brinell hardness (500 kg. load with 10-mm. diameter ball), 135; shearing strength, 42,000 lb. per square inch; and modulus of elasticity, 10,600,000 lb. per square inch. The average coefficient of thermal expansion, between —50 deg. F. and 150 deg. F., is 0·0000125 per deg. F. and the weight, 174 lb. per cubic foot. The resistance to corrosion of 14S-T alloy plates used in the construction of the span was increased by employing the process known as "Alcladding." In this, a layer of a different alloy, of greater corrosion resistance, is rolled on to both surfaces of the plate. The layer, which has a thickness of about 5 per cent. of the finished plate, is of such chemical composition that when it is cut or broken, and is wetted by a conducting liquid, such as salt water, a local electric circuit is set up, resulting in the sealing of the defect.

# RAILWAY BRIDGE WITH ALUMINIUM SPAN.

Fig. 3. Hand Fitting Flange Cover Plates.

Fig. 4. Assembling Cross Frame.

The action also serves to protect the rivet ends, which are not Alcladded.

The general construction of the span can be seen from Fig. 2, on page 529, which shows it being lifted into place during erection. It consists of two plate girders 10 ft. deep and 100 ft. long. The web plates, $\frac{3}{8}$ in. thick, are made up of four 25-ft. sections. The flange angles are 8 in. by 6 in. by $\frac{5}{8}$ in., and the web-stiffening angles are 5 in. by $3\frac{1}{2}$ in. by $\frac{7}{16}$ in., this latter dimension being increased to $\frac{3}{4}$ in. for the end stiffeners. The cover plates are 14 in. wide by $\frac{5}{8}$ in. thick. To stiffen the deep aluminium web, a horizontal 5 in. by $3\frac{1}{2}$ in. by $\frac{7}{16}$ in. angle is fixed between the vertical stiffeners on the inside of each girder, about 30 in. from the top of the web. The top lateral struts are 6 in. by 4 in. T-sections, with 8 in. by 6 in. T-diagonals, the lower lateral system consisting of 6 in. by 4 in. T's both for struts and diagonals. For the end cross frames, the top struts are made up to two 5 in. by 3 in. angles and the bottom struts of two 4 in. by 3 in. angles; the diagonals consisting of two 6 in. by 3 in. T's. There are seven intermediate cross frames with 6 in. by 4 in. struts and diagonals consisting of one 6 in. by 4 in. T-section.

The design of the span was worked out in general accordance with the recommendations given by the late Leon S. Moisseiff in his manual entitled *Design Specifications for Bridges and Structures of Aluminium Alloy* 27 *S-T*. As the mechanical properties of 14 S-T. alloy, of which the span is built, are superior to those of the 27 S-T alloy on which Moisseiff's calculations were based, it was considered that the new design would have an ample factor of safety. The basic unit stress in tension was taken as 21,000 lb. per square inch, the value used by Moisseiff. Consideration had to be given to the properties and behaviour of the neighbouring steel spans. If the live-load unit stresses were the same for a steel girder as for an aluminium girder of equal depth, the deflection of the latter would be about 2·8 times that of the former. This greater deflection could be reduced either by increasing the depth of the girder or decreasing the live-load unit stress. There were limitations to the use of either of these procedures. An appreciable reduction in unit stress would not have been practicable on the score of expense, and a considerable increase in depth would not have been consonant with a satisfactory appearance for the completed bridge. The steel girders are 9 ft. deep, and as a compromise it was decided to make the aluminium span 10 ft. deep. This procedure did not give the maximum economy in material, but it was within the economic range, reduced deflection and had little effect on the appearance of the completed bridge. It will be clear from Fig. 1 that the aluminium span is deeper than the others.

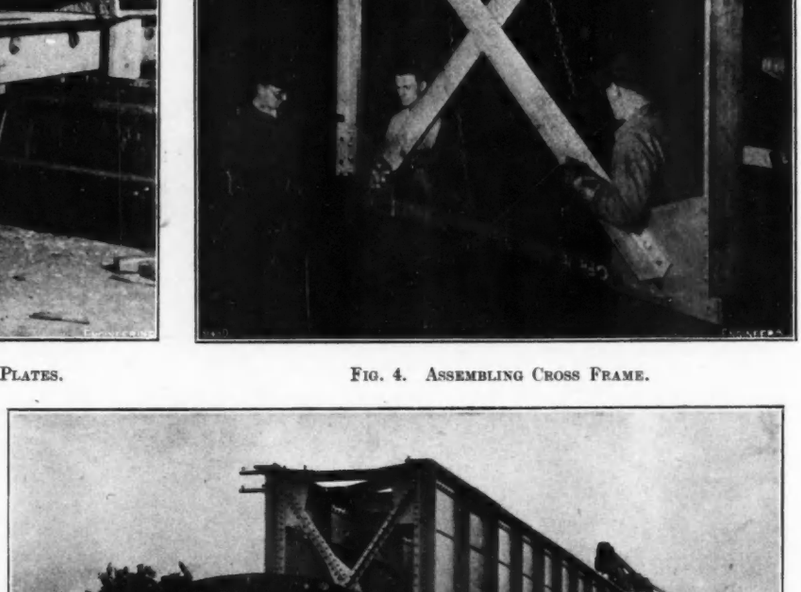

Fig. 5. Transporting Completed Aluminium Span.

The span is designed for an extreme fibre tension, in rolled sections, girders and built-up sections, of 20,800 lb. per square inch. The shear stress in the plate-girder webs is 12,500 lb. per square inch; in cold-driven rivets, 10,000 lb. per square inch; and in hot-driven rivets, 8,000 lb. per square inch. The two types of rivet are made from different material, as is explained below. The dead load on each girder of which the span is made up is 27,500 lb.; the live load, 220,300 lb.; and the impact, taken as 55 per cent. of the live load, 122,200 lb. The total maximum shear load is accordingly 370,000 lb. The maximum dead-load moment is 669,000 ft.-lb.; the maximum live-load moment, 4,628,000 ft.-lb.; and the maximum impact-load moment, 2,569,000 ft.-lb. These values make up a total maximum moment of 7,866,000 ft.-lb.

At the time the design of the bridge was being worked out, heavy plate of Alclad 14 S-T alloy had never been produced in widths as great as 10 ft., and the Aluminum Company accordingly rolled a number of plates 10 ft. wide, $\frac{3}{4}$ in. thick, and about 26 ft. long, and submitted them to test and examination for physical properties and flatness. They were satisfactory, and it was on the basis of these plates that the decision was made to form the girder webs of four plates 25 ft. long. It was not considered desirable to attempt to exceed the 26-ft. length of the test plates. The maximum live load on the bridge is imposed by 70-ton loaded wagons, and under this condition the deflection of

the span is 1·25 in., as compared with 0·45 in. for the steel spans. The aluminium span is built with a camber of 1½ in. at the centre. The span was designed by the General Engineering Department of the Aluminium Company, Pittsburg, Messrs. Hardesty and Hanover, of New York, acting as consulting engineers. All material was supplied by the Aluminum Company and the span was manufactured by the Bethlehem Steel Company at their works in Rankin, Pa.; it was also erected by this firm. The steel spans were built in the same shops and an incidental advantage of the aluminium construction was illustrated by the fact that, owing to weight considerations, it was necessary to ship and erect the girders of the steel spans separately and assemble the lateral bracing in the field; whereas the aluminium span was completely assembled in the shops and shipped and erected as a complete unit.

No operational difficulties were encountered by the Bethlehem Steel Company in the construction of the span and they were able to utilise their standard tools and methods. The only piece of special equipment required was an electrically-heated furnace for the rivets which were driven hot. Most of the rivets used were ⅞ in. in diameter, made from A 17-S-T aluminium alloy. This material contains 2·5 per cent. of copper and 0·3 per cent. of magnesium. These rivets were driven cold by means of an 80-ton air-operated squeeze ram. When driven, they have an ultimate shearing strength of 33,000 lb. per square inch. The hot-driven rivets were used in positions in which the ram could not be used, notably for the connections between the gussets of the cross frames and the inside vertical stiffener angles of the girders. These hot-driven rivets were made from 53 S-W aluminium alloy, which contains 1·3 per cent. of magnesium, 0·7 per cent. of silicon, and 0·25 per cent. of chromium. When in position they have an ultimate shearing strength of 24,000 lb. per square inch. They were driven by pneumatic hammers at a temperature of about 1,040 deg. F. They develop their strength through the "quenching" received by contact with the cold metal and tools.

All holes were drilled in the aluminium plates or sections which were ½ in. or more in thickness; thinner parts were punched. In both cases, the holes produced were $\frac{11}{16}$ in. in diameter and were afterwards reamed when the parts to be connected had been assembled together. The operation of the initial drilling of two of the web plates together is illustrated in Fig. 6, on page 540. The first stage in the construction of the span was the building up of the top and bottom flange assemblies for the web plates. This operation is shown in Fig. 7, on page 540. The flange angles were first bolted together against spreaders $\frac{5}{8}\frac{1}{4}$ in. in thickness, that is, $\frac{3}{4}$ in. greater than the thickness of the web plates which were subsequently to occupy their position. The cover plates were then fitted to the flange angles, all metal-to-metal contact surfaces being covered with an aluminium-pigmented caulking compound containing zinc chromate. Excess of the compound was squeezed out during the fitting and driving of the rivets. In order to ensure complete bearing, the cover plates were carefully fitted by hand. This operation is illustrated in Fig. 3, opposite. The $\frac{11}{16}$-in. drilled holes were first aligned by passing an $\frac{11}{16}$-in. diameter reamer through them and then enlarged with a $\frac{5}{8}\frac{7}{4}$-in. reamer. The rivets were then inserted and closed by the 80-ton squeeze ram visible in Fig. 7, on page 540.

The next stage was the fitting of the flange assemblies to the web plates. The lower flange assembly was secured by clamps to rails bolted to the shop floor, as shown in Fig. 8, on page 540, the clamps being set so that the flange was given the necessary 1½-in. camber. The web plates were lowered into position, the stiffener angles fitted, and the top flange assembly lowered into position, as shown in Fig. 9, on page 540, in which one of the flange assemblies for the second girder can be seen in the foreground. When the girder had been riveted up and completed, it was laid on its side and the cross frames were secured to the inside stiffener angles, the second girder, previously completed, then being lowered into position and riveted o the cross frames. The manufacture of one of the latter is illustrated in Fig. 4, opposite. This shows the fixed machine used for riveting the gusset plates and which, when convenient, was used instead of the 80-ton squeeze ram slung from a crane, which is shown in Fig. 7, page 540. After completion, and before shipment, the span was painted with a priming coat of zinc chromate and two coats of aluminium paint. A 6-ft. wide panel between two vertical stiffeners was left bare in order that the weathering properties of the aluminium-alloy parts could be studied.

The completed span weighs 53,000 lb. and was shipped and handled as a complete unit. It was transported to site by rail on two flat cars, as shown in Fig. 5, opposite, and was lifted into position by a 30-ton locomotive crane. The handling operation is illustrated in Fig. 2, on page 529. The crane was capable of lifting only one girder of the steel spans. These were erected separately, and the cross frames and laterals of the steel spans were assembled on site by men working on suspended platforms. It cannot be assumed that the facility with which the aluminium span was erected would represent a saving in over-all cost which would balance its greater manufacturing cost, but it is possible that, in some special cases, this simplification of erection procedure might, in itself, justify the employment of aluminium as a structural material. The span is carried on steel rockers and, in order to allow for the high coefficient of expansion, these are made 13½ in. high, permitting an end movement of 2 in. on each side of the vertical. The rocker is set to be in the vertical position at 100 deg. F.

## LITERATURE.

*Manual for Process Engineering Calculations.* By LOYAL CLARKE. McGraw-Hill Book Company, Incorporated, 330, West 42nd-street, New York 18, U.S.A. [Price 6 dols.]; and McGraw-Hill Publishing Company, Limited, Aldwych House, Aldwych, London, W.C.2. [Price 30*s.*]

THE designer of plant for chemical process work has a very specialised field of activity, and consequently requires a great deal of data not to be found in the ordinary engineering reference books. His needs are well catered for in the present volume, in which the kind of information most likely to be sought by those in the chemical manufacturing industries has been condensed in a style somewhat similar to that of a good engineering pocket-book. The book is an addition to the Chemical Engineering Series of the publishers, and the author, who is chemical engineer to the Celanese Corporation of America, has synthetised in a handy form an immense amount of useful data from recent American chemical publications, giving full references to his sources. He has classified the collection probably as well as it could be done and has given it continuity by brief practical remarks.

The ground covered is so extensive that it is difficult, within the limits of a short notice, to give an adequate idea of the contents of the work. With regard to constructional materials for particular purposes, the reader can hardly fail to find out how any kind of metal or variety of synthetic rubber, plastics, etc., is likely to behave in the presence of corrosive or other trying conditions. He is further assisted by a ten-page table which records the actual materials currently used for equipment exposed to the attacks of one or more of 40 different chemicals. Altogether, 96 different constructional materials are listed in this connection. A section on "Thermodynamic Data" comprises tables of critical pressures and temperatures, specific heats, vapour pressures, heats of formation, etc., for a large number of chemical substances and oils, as well as the thermodynamic equations of most use to the chemist. Piping, hydraulics and the flow of fluids form the subjects of the next section, with numerous tables of friction loss for liquids of various viscosities, flowing through pipes of different sizes. The principal formulæ for heat transference and combustion calculations are also given; though, in regard to the latter, it may be pointed out that a formula which is theoretically correct for computing the excess air from the composition of the flue gases when no CO is present cannot legitimately be adjusted for the presence of CO in the way stated by the author. This, however, is a small matter, for a correct formula for such cases, accompanied by a nomogram to avoid the trouble of its evaluation, will be found on the following page. Nomograms, indeed, constitute a notable feature of the book, which contains over 50 of them.

Subsequent sections on power plant, pumps, fans, blowers and compressors, and water treatment—especially the last—are likely to be thought more than a little sketchy by the ordinary engineer, who will also hardly be concerned with the chapter on the processes of absorption, stripping and distillation, which belong to the technique of rectification. On the whole, the book can be recommended with confidence to the class of engineer for whom it is intended, and to others whose duties give them a special interest in chemical engineering.

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*Rolling Bearings.* By R. K. ALLAN, A.M.I.Mech.E., M.I.P.E. Second edition. Sir Isaac Pitman and Sons, Limited, Parker-street, Kingsway, London, W.C.2. [Price 30*s.* net.]

No form of mechanical component presents a more deceptive appearance of simplicity than does that large class of ball and roller bearings, or as the author of this admirable book categorically describes them, rolling bearings; and none makes heavier demands upon the skill and ingenuity of the designer, the metallurgist and the manufacturer. The user—meaning thereby the purchaser of machinery embodying rolling bearings—has little more to do than to follow out the makers' instructions regarding fitting and lubrication; but half a century of scientific investigation and the development of production methods of the highest standards of precision have contributed to make this possible, and, even now, those most expert in the subject are the most ready to admit that there are still wide fields of research to be explored.

Mr. R. K. Allan, in this "comprehensive treatise covering history, theory, design and practical application and use of ball and roller bearings" (to quote from his title page), has produced a text-book which, now that the few errors, mainly typographical, which appeared in the first edition, have been corrected, should rank as an engineering classic for many years to come. In a sense, it is a successor to the *Handbook on Ball and Roller Bearings* of the late A. W. Macaulay, published in 1924; and, as both authors had the advantage of the same background—that of the Skefko Ball Bearing Company's establishment at Luton—a certain resemblance between the two books is only natural. Many developments, however, have taken place in the intervening years, as Mr. Allan duly records, and there was a definite need for a more up-to-date survey of both theory and practice. This he has provided in 16 chapters or "sections," as he prefers to call them, each characterised by a practical outlook and a clarity of style that are not always found in conjunction. The first section is historical, and the next three are sufficiently described by their titles of "Fundamental," "Elemental" and "Materials and Manufacture." The theoretical survey concisely summarises the work of Hertz, Stribeck, Goodman, Palmgren and others, and is followed by the sections covering current practice in the design and use of rolling bearings. The "Miscellaneous" section contains a varied assortment of data and many items of interest—for instance, that the highest speeds attained range up to 120,000 r.p.m., and the heaviest recorded load is 1,000 tons, on a bearing of only 46½ in. outside diameter; but this section would be improved if the tables were set in type instead of being reproduced from handwritten originals. There is a comprehensive bibliography, a list of manufacturers of rolling bearings in Europe and America, and an adequate index.

The new matter in this edition is relatively small in extent, and is mainly in Section III ("Elemental") on pages 60 and 61; but there are several corrections to formulæ, notably in equations 6.81, 7.47, 7.48 and 7.49, 10.1 and 10.11. One error which has escaped correction in the present edition occurs on page 105, where the expression for cost, following equation 5.11, has been inverted.

# BRITTLE FRACTURE IN MILD-STEEL PLATES—I.

ONE of the major research problems of the recent war was the investigation of the cracking of mild-steel plates, which was brought into prominence by the structural failure of certain merchant ships of welded construction. One of the best-known cases, and certainly one of the most spectacular, was that of the welded tanker Schenectady, which was the subject of an article on page 371 of our 155th volume (1943); but there were others of great technical importance, and, of course, there were numerous practical problems associated with the development of welding technique which required early elucidation. That so many of them arose in connection with welded work did not imply any wholesale condemnation of welding as a process; it was the natural outcome of the greatly increased use of welding, and that, in turn, derived from the prosaic fact that a man could be trained to be a good welder in fewer months than the training of a riveter, to a corresponding pitch of efficiency, would require years.

To deal primarily with those failures which were attributable to inexperience on the part of the welder or the designer of welded work, the Admiralty set up, in 1940, the Admiralty Ship-Welding Sub-committee, under the chairmanship of Sir Amos Ayre, K.B.E.; and when, as indicated above, a number of serious failures occurred in welded ships during the early years of the war, the matter was naturally regarded by this sub-committee as one of extreme importance to this country, although the actual ships were of foreign construction. In 1943, therefore, the Cambridge University Engineering Laboratory, under Professor J. F. Baker, O.B.E., was requested by the Admiralty to investigate the whole problem, the cause of these failures then being entirely unknown. By 1945, work at the laboratory had isolated the major cause of the failures, which was shown to lie in the ship plate used.

At this stage, it was decided that a conference of engineers and metallurgists would be useful to ventilate the problem. This conference was held at the Engineering Laboratory, Cambridge, in October, 1945, under the auspices of the British Iron and Steel Research Association, the Admiralty Ship-Welding Sub-committee, and the British Welding Research Association. In addition to members of the Engineering Laboratory and of these three bodies, there attended representatives from many steel firms, from Lloyd's Register, the Service and other Government departments, the Cavendish Laboratory, the National Physical Laboratory, the United States Coast Guard, and several other interested bodies; in all, 51 persons. The chairman was Dr. (now Sir) Andrew McCance, F.R.S., chairman of the Council of the British Iron and Steel Research Association.

The nine papers read and discussed made it clear that the major cause of the failures was, indeed, attributable to ship plate, and indicated the lines of research necessary for ascertaining the detailed cause and cure of the phenomenon of brittle fracture. Much subsequent work has been done along the lines indicated, by the Cambridge University Engineering Laboratory and by the British Iron and Steel Research Association, and at the works of Messrs. Colvilles, Limited. Some of the results so far obtained were discussed at the November meeting of the Iron and Steel Institute, and others are in course of publication by H.M. Stationery Office. Such results, however, and future progress must rest largely upon the knowledge assembled and discussed at the conference of October, 1945, a full report of which we commence below and will continue in subsequent issues.

The material before the conference was presented in a series of short papers, the titles and authors being as follows. After a brief introduction by Dr. McCance, explaining the origin and scope of the conference, Professor J. F. Baker outlined "The Problem of Brittle Fracture in Ship Structures." He was followed by Dr. C. F. Tipper, M.A., who dealt more specifically with "Brittle Fracture of Mild-Steel Plates"; Mr. J. L. Adam, C.B.E., who spoke on "Brittleness in Ship Steel"; Mr. William Barr, R.C.N.C., who reported on "Brittle Failure of American Ship Plates"; Dr. E. Orowan, who dealt with "Fracture and Notch Brittleness in Ductile Metals"; and Professor N. F. Mott, F.R.S., whose address was entitled "Fracture of Metals: Some Theoretical Considerations." At this point, Dr. I. G. Slater and Mr. J. N. Bradley, B.Sc., introduced a discussion on the papers submitted by Professor Baker and Dr. Tipper, and then two more papers were read, Mr. D. E. J. Offord dealing with "Fundamental Physical and Metallurgical Aspects of Brittle Steel," and Lieut.-Commander E. M. MacCutcheon, of the United States Coast Guard, presenting "An American Point of View." Finally, there was a general discussion, and a summing-up by the chairman, Dr. McCance.

### BRITTLE FRACTURE IN SHIP STRUCTURES.

Professor J. F. Baker, in introducing his paper, said that there were many problems attractive to the research worker in the behaviour and design of welded ships. The early experiments at Cambridge with welded plates under restraint, for instance, convinced him that, if the presence of high residual stresses were the only factor, no welded ship or other structure would survive for very long. When Mrs. Tipper's early tests showed the susceptibility of some of the ship plates to brittle fracture with no appreciable resilience, it seemed clear to him that they had isolated the major factor involved in catastrophic failures.

Little is known, continued Professor Baker, of the real magnitude or of the distribution of the stresses existing in a riveted ship subjected to the conditions which provide the severest test. All that the designer of a riveted ship knows is that, by assuming certain static loading conditions, adopting reasonably low permissible stresses and certain simplifying design assumptions as a basis for calculation, he designs a structure which gives satisfactory service and does not fail under the severe and complex loading conditions, dynamic as well as static, which the ship meets in its life. The designer of the welded ship, for the most part, has followed exactly the same design rules, and so produces a structure differing little in the proportions of its main members from those of the corresponding riveted ship, though those members are joined together by welding. It is natural, therefore, that, in searching for the cause of the failures of welded ships, the primary or local effect of the welds should first become suspect.

Failures of steel structures are, on the whole, rare. When they do take place, for reasons other than fatigue—for instance, due to excessive loading or to maldistribution of material—they usually follow from parting of the connections, from large deflections due either to elastic instability of the members or to overstrain producing plastic deformations. A number of the fractures found in welded ships take none of these forms. Their common characteristic is the development of large cracks, splitting members without any indication of plastic deformation before fracture. Paint or scale still adheres to the surface of the material even in the immediate vicinity of the crack. The exposed surface of the crack presents the typical appearance of a cleavage fracture. Microscopic examination reveals no trace of plastic deformation of the crystal grains. The mode of failure is, in fact, very different from what one would expect in a structure built of ductile material, showing, as it does in the usually accepted static tensile test, a well-defined yield and a big elongation.

The effects arising from the substitution of welding for riveting, which must first become suspect, can be divided into the primary effects, namely, faults and weaknesses in the welds, locked-up or residual stresses in the weld and in its immediate neighbourhood, and abrupt changes in cross-section of the structure; and the secondary effects due to the almost perfect continuity of the structure, comprising self-straining, temperature stresses, and fatigue. While there is evidence that faults and weaknesses in the welds may initiate local cracking, these defects will not in themselves account for the rapid propagation of cracks on an extensive scale. It must be remembered that, as is the case with most catastrophic failures, there may be more than one contributory cause.

It is well known that high local "locked-up" or "residual" stresses are produced in the process of welding. They arise from the plastic deformations which occur during welding, in the weld and in a zone of the plate material parallel to the weld. Such stresses will always be present unless the structure has been "stress-relieved" by heat treatment, a process which seems impracticable in the case of a ship. There is widespread opinion that residual stresses are responsible for the occurrence of brittle fracture. This is natural enough, since their existence is one of the few characteristics which distinguish a welded ship from a riveted ship.

Experience with welded plate-girder bridges in Germany shows the possible dangers of residual stresses. A number of bridges, fully welded from a high-tensile steel of 33 tons per square inch ultimate tensile strength and a composition of 0·2 per cent. C, 0·5 per cent. Si, 1·2 per cent. Mn, 0·03 per cent. P, 0·02 per cent. S, 0·1 per cent. Cu, and 0·1 per cent. Mo, developed the same type of failure, usually starting in the joint between web and flange, which is being experienced in welded ships. The stress conditions in these fillet welds would not be dissimilar to those in sheer-strake stringer connections, which are, in a number of cases, suspected of having initiated the cracks in ships. In order to throw more light on the behaviour of these girders, C. M. Bohny and H. Busch* fabricated three identical large plate girders, about 3 ft. deep and 20 ft. long. Two girders were stress relieved by heat treatment at 600 deg. C. When they were loaded, they deformed plastically and could not be fractured. The one girder which was not stress-relieved fractured suddenly with a loud report when loaded, and showed comparatively little indication of plastic deformation. This is by no means conclusive evidence, but it shows that serious consideration must be given to the influence of residual stresses.

The presence of residual stresses means that, at any particular state of loading, the stresses at some points in the structure will be greater, and at others less, than in a similar structure initially free from residual stresses. It is possible, therefore, that the elastic limit of the structure may be increased or reduced by the presence of residual stresses. It is conceivable, also, that the failing load will be reduced, but, for a structure built of ductile material, this is by no means certain. Even assuming that residual stresses reduce the failing load of the structure by increasing the stress concentration at some points, it is not clear why they should produce the catastrophic, almost explosive, failures with which they are credited. It has been generally accepted, and has been a great comfort to structural designers, that plastic flow of a ductile material tends to "iron out" stress peaks and makes it permissible to proportion a member in a framed structure on the basis of total resultant reactions.

If the vast field of experimental work on the behaviour of mild steel under static systems of stress at normal temperatures is surveyed, no evidence of brittle fracture will be found. Axial tension and compression, pure shear and bending in beams, two-dimensional states of stress as they can be realised in thin tubes, have never been found to produce fracture not preceded by very considerable plastic deformation. Three-dimensional states of stress, as far as it has been possible to reproduce them in the laboratory, have also been shown to produce plastic deformations.† From all this evidence, the conclusion has been drawn that plastic deformation is a direct outcome of shear stress and will always occur if shear stresses of sufficient magnitude are present. Conversely, if shear stresses are absent, plastic deformation cannot occur and the material will eventually fail in a brittle manner when the normal stresses overcome the cohesive strength of the material. Although shear is thus recognised to be the cause of plastic flow, it is still debatable whether it is the value of the maximum shear stress or of the shear strain energy which is the factor determining when flow will begin. The more widely accepted

* *Stahl und Eisen*, vol. 64, page 365 (1944).

† G. Cook, *Proc. Roy. Soc.* A, vol. 137, page 559 (1932).

view, for which there is most experimental evidence, is that yield takes place in a ductile material under any uniform system of stress when the shear strain energy reaches some constant value U.

If a state of stress exists such that, on the principal planes of stress, there act three tensile stresses not very different from each other, the value of the shear strain energy will be small—smaller, in fact, than U, the critical value which produces plastic flow; while the principal stresses may be large enough to overcome the cohesion of the material, so that a brittle fracture will result. This behaviour under a triaxial state of tensile stress is unconfirmed by experiment, simply because it has not yet been possible to produce such a homogeneous state of stress to order. Something approaching that state might have been present at the junction of the web and flange in the plate girder referred to above, thus causing a brittle fracture to be initiated. It could not have been present throughout the flanges and web of the girder, and the existence of a state of triaxial stress at one point cannot, therefore, explain fully the complete collapse in this case, any more than it can in the case of ship failures, unless the material of the girder was prone to propagate a crack once it had started. It can, however, be a contributory cause and must not be ignored.

The experimental difficulties in reproducing a system of triaxial equal tensile stresses have made it impossible to decide whether materials, which in other tests exhibit identical behaviour, differ in respect of such a system of stresses. It is possible that different steels which had comparable strengths, as measured by the usually accepted tests, would fracture at very different loads if they were subjected to triaxial tensile stresses.

It is important to remember that most experimental work, directed to the study of the behaviour of materials in the region for which Hooke's Law does not hold, endeavours to realise homogeneous states of stress. The reason is that, the theory of elasticity being inapplicable in this region, it is only for such states that the magnitudes of the stresses can be accurately forecast. The state of stress present in actual structures, however, is seldom homogeneous. There is, therefore, a gap between the conditions in the laboratory, where the data on the behaviour of materials are obtained, and those in practical problems to which the data are applied. This gap is usually bridged by the assumption that every element of the material, small enough for its state of stress to be considered homogeneous, will exhibit the same behaviour up to failure as a large test piece under the same homogeneous state of stress. This may be a dangerous assumption. The behaviour of the element may well be dependent not only on its own state of stress, but on the state of the surrounding material.

The study of the behaviour of mild steel under the influence of non-homogeneous states of stress has been concentrated on problems of immediate practical importance, the bending of beams, eyebars in tension and thick-walled tubes subjected to internal pressure (autofrettage). A large amount of work has been done, though with a somewhat different object, on round notched bars in tension.

A satisfactory explanation—the classical conception of the theory of plasticity—has been obtained for the plastic bending of beams. When a mild-steel beam is subjected to transverse loading, a non-homogeneous state of stress is developed. When the most highly stressed fibre reaches yield, it does not follow the behaviour of a tensile test piece, but is influenced by the state of stress of the rest of the material in the member. Similar behaviour is found in continuous stanchions carried into the plastic range.* The longitudinal fibres in these members, subjected to a state of stress approximating to pure tension or compression, do not suffer large extensions when yield is reached, because they cannot deform independently of the rest of the material. Their deformation is subject to certain geometrical conditions.

Something more than the simple conception which appears to fit the behaviour of beams and columns satisfactorily is necessary to explain the behaviour of eyebars or notched bars in tension or thick-walled tubes under internal pressure,* and an even wider deviation from the idea that each element behaves as the correspondingly stressed test piece is inevitable.

It is well known that, by notching a flat bar and pulling it in tension, stress concentrations are developed. According to the simple theory of plasticity, it would follow that, when the load in the bar was increased, yielding would begin as soon as the stress peaks reached the yield point of the material, and that further increase in load would produce a gradual extension of the plastic zones, until eventually the cross section was uniformly stressed and "yield" of the bars as a whole would be reached. The average load per unit area at which this yield took place would then be the same as the yield-point stress in an unnotched bar.

Experiment does not bear this out. Wherever the yield of a notched bar has been observed, it appears to have taken place at a higher average load per unit area than the yield point of an unnotched bar. This higher average stress might be explained by assuming that the deformation of the more highly stressed part of the bar is so far in advance of the centre portion that it has already entered the work-hardening range while the central portion is still elastic. But this assumption is not quite satisfactory, because it leads to disagreement with experiment, in that fracture would be expected to begin as soon as the stress peaks reached the ultimate tensile strength of the material. The average load per unit area at which fracture took place would then be not greater than the ultimate tensile strength of the material. In actual fact, as is well known from the work of P. Ludwik and R. Scheu,† W. Kuntze,‡ G. Sachs,§ and J. McAdam,‖ the ultimate tensile strength of a notched bar may be nearly twice as great as the ultimate tensile strength of an unnotched specimen. It is not the purpose of this note to suggest that the structural discontinuities in a ship make it behave exactly as a notched bar in tension, but, until a rational theory of behaviour in the plastic range is available, the discrepancies noted in tests and the theories put forward to explain them must not be neglected.

The common element in the more recent theories can be summed up in the statement that yielding does not always occur in a ductile member non-uniformly stressed when the strain in the most highly stressed fibre reaches that value at which, if the state of stress had been uniform, the elastic limit or the yield point of the material would have been reached. The behaviour of an element or fibre in a large mass of material is dictated by the state of stress of the surrounding material. Bierett,¶ carrying out tests on large eye-bars, found that the elastic (reversible) stress in the vicinity of the eye could be much higher than the yield point of the material. His results were confirmed by Eiselin**, and Rinagl†† Cook‡‡ and L. M. Morrison§§ produced similar evidence in tests on thick tubes, which suggests a raising of the yield point under the stress peaks.

The explanation may be that the process of yielding cannot be confined to a point but must seize a large number of crystal grains, since it can only take place in layers. It might well be possible that yielding under the stress peaks is retarded, and the stress at these points increased elastically until a sufficiently large number of appropriately disposed crystal grains has also reached stresses sufficiently high to enable them to participate in the formation of such layers of yield.¶¶

To keep the argument above as simple as possible, reference has not been made to the multi-axial state of stress present in a notched bar or similar test. In the case of a flat plate loaded in the plane of the plate, the existence of a bi-axial system of stress can only account for a small increase in the yield-point stress. It could never account for the absence of yielding and for deformationless tearing. The increase in "yield point" can probably be brought into harmony with the conception that the behaviour of an element in a member is identical with that of a test piece similarly stressed if the stresses in the member are not bi-axial but tri-axial.

Whatever theory will eventually be found to explain all the phenomena, there appears to be no doubt that the influence of notches or discontinuities, producing non-homogeneous states of stress, is to increase what may be termed "flow resistance" under the stress peaks, which, in turn, might permit the peak stresses to be raised sufficiently for the cohesion of the material to be overcome and a brittle form of fracture to be initiated. As has been stated, however, this does not explain the catastrophic failure of ships, since it is not possible to argue that the whole section of a vessel traversed by the fracture was in such a state of stress that ductile fracture would everywhere be inhibited.

The discontinuities in the main and secondary structure, which are inevitable in a ship, can give rise to stress concentrations. In some early designs of welded ships, sufficient care was not given to the finer points of detail design, but considerable attention has been given in later ships to reducing the severity of the stress concentrations. As already stated, it is inconceivable that any "flow resistance" introduced by the discontinuities could affect any large part of the structure. The effects introduced by the continuity of a welded structure, and described above as "secondary," cannot, at the worst, be very different from those dealt with above.

It is very difficult to fabricate a redundant structure without introducing some degree of initial stress due to lack of perfect fit of the members. It appears that, in the early days at least, considerable force was often necessary to bring the large and stiff prefabricated units of ships together accurately for final welding. This might well introduce heavy self straining, and develop high initial stresses distributed over the whole cross-section of the ship.

The submerged part of the hull of a ship will remain at a temperature which is relatively constant while the upper deck will be subjected to considerable temperature changes, even in the course of a single day. There are no data of the relative magnitudes of the temperature stresses developed in welded and riveted ships, but the greater continuity of the former may give rise to appreciably higher stresses. Though there is not the slightest resemblance between the serious brittle fractures observed in welded ships and normal fatigue fractures, except the absence of plastic deformation, it is impossible to rule out fatigue as a possible contributory cause which might start a crack.

If fatigue were a greater danger in welded than in riveted ships, it might be due to the greater rigidity and the very much smaller damping capacity of the former. It is conceivable that resonance might be set up more easily in any part of a welded ship if a periodic disturbance of a suitable frequency were set up by the engines or other machinery. Experience of vibrations shows that they would have to be of very small amplitude if they were not to appear alarming to the crew. However, while vibrations of small amplitude might not cause fatigue failure in a riveted ship, it is conceivable that superimposed on an existing static stress near the yield point of the material, arising in a welded ship from one of the causes enumerated above, they might give rise to trouble, as indicated by the work of Professor B. P. Haigh.* There is, however, experimental evidence, cited by D. Rosenthal and T. Norton,† that residual stresses are gradually reduced by a superimposed alternating stress, but considerably more investigation is necessary before this claim can be established.

While any or all of the secondary effects dealt with above might cause more or less local conditions of high stress, eventually leading to failure of the material, none of them, as was found in the case of

* J. F. Baker and J. W. Roderick, *Trans. Inst. of Welding*, vol. 1, No. 4, page 206 (1938); *ibid.*, vol. 3, No. 2, page 83 (1940); and vol. 5, No. 3, page 97 (1942).

* G. Cook, *Phil. Trans. Roy. Soc.* A, vol. 230, page 103.
† *Stahl und Eisen*, vol. 43, page 999 (1923).
‡ Lecture at Congress of Elements of Machines, Berlin, 1936.
§ *Trans. Amer. Soc. of Metals*, vol. 31, No. 1 (1943).
‖ *Trans. Amer. Inst. of Mining and Metall.* (1942).
¶ *Mitt. d.d. Materialprufungsanst.*, Special Issue XV (1931).
** *Bauingenieur*, 1924, page 250.
†† *Second Congress, Internat. Assoc. for Bridge and Struct. Eng.*, page 1561.
‡‡ *Loc cit.*, page 4.
§§ *Proc. I. Mech. E.*, vol. 142, page 193 (1939).
¶¶ W. Kuntze. *Stahlbau*, 2 (1935).

* *Trans. I.N.A.*, vol. 81, page 84 (1939).
† Suppt., *Jl. Amer. Welding Soc.*, vol. 8, page 63 (1943).

residual stresses, could produce the long brittle fractures found in ships.

Though static conditions of loading are assumed by the ship designer when proportioning the members of the structure, there is little doubt that the ship is most severely tested by dynamic loads due to wave action. The ability of a structure to withstand impact loads is measured by the resilience of the structure. Though methods of structural design based on resilience or energy absorption are not usual, they have been developed during the war for application to air-raid shelters and structures to protect plant from the effects of bomb explosions. It was found that the essential features of an efficient protective structure were continuity and ductility. Continuity, since a high degree of redundancy is desirable, and ductility of the continuous structure as a whole since the amount of energy which can be absorbed in the elastic range or by a brittle structure is very small. In fact, in order to produce efficient, that is, not impracticably massive, structures, advantage had to be taken of the great increase in resilience provided by plastic deformation. There is much in common between a ship and such a protective structure; they are both called upon at times to absorb relatively large amounts of energy. How far has a welded ship the two features found to be essential in a protective structure? There should be no doubt about its continuity, nor, when built of mild steel, of its ductility. War-time experience has demonstrated the ability of a welded ship to stand up to the shock due to nearby underwater explosions more efficiently than the less continuous riveted ship. It is clear, however, that, if the material of which the ship was built were not ductile, it could not absorb any appreciable amount of energy. If, for instance, a ship's plates were made of cast iron, no one would be surprised at the form of fractures which have been experienced.

The plate used in welded ships has to satisfy a specification demanding an elongation in the normal tensile test which should ensure the material being reasonably "ductile." Tests have been carried out in the Engineering Department, Cambridge, on normal test samples cut from a plate taken from a ship which had fractured. The tests showed that the material satisfied the specification, giving an elongation of 20 to 25 per cent. on an 8-in. gauge length and showing a normal fibrous fracture. Further tests were then carried out on 3-in. wide strips of the plate, in one edge of which a 45-deg. notch had been made, ¼ in. deep, the radius at the bottom of the notch being comparatively large, of the order of 0·004 in. The specimens were pulled in a tensile testing machine in the usual way at normal room temperature. Their behaviour was strikingly different from the behaviour of the unnotched specimens.* At a stress close to the normal yield stress of the material, a crack appeared at the bottom of the notch which suddenly led to fracture of the whole cross-section with no local deformation of the plate. The character of the fracture resembled that of the original plate fracture which had appeared in the ship. Similar fractures have been produced in the same way in plates from other sources.

The importance of these results is obvious. If a structure is incapable of local plastic deformation, it cannot absorb anything but a small amount of energy without fracture. In the specimens of plate under discussion, the notch represented the kind of imperfection that is found in a welded ship or any other similar structure. In a structure built of this particular plate, therefore, it is not surprising that a serious fracture occurred.

Further tests showed that all steel plate did not behave in this striking way when an imperfection was present. It has not yet been possible to identify the critical properties in the steels which divide them into the two classes, one failing with considerable elongation and consequent large energy absorption, and the other failing with a brittle cleavage type of fracture with practically no elongation and no appreciable energy absorption, but enough work has been done to show that temperature is a critical factor. All steels will give a brittle fracture at a sufficiently low temperature. What have not been determined are the critical properties which produce such fractures in certain steels at relatively high temperatures.

It will be seen that the properties of the material assume great importance in this problem, for while the effects set out above—faults in the welding, residual stresses, abrupt changes in cross-section, self-straining, temperature stresses and fatigue—may constitute favourable conditions for the initiation of a crack, it will only propagate in a catastrophic way when the material, for reasons as yet unknown, is prone to the cleavage type of fracture. It is important, therefore, to investigate the causes of low ductility in mild steel. To facilitate this work, a résumé of the present state of knowledge has been prepared as an appendix to this note. A more complete study of the design of structures to withstand impact is also necessary, since, at the present time, crude empirical rules only are available for proportioning the connections between members of structures which have to withstand shock.

*(To be continued.)*

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## AIR-BRAKE ASSEMBLY FOR MINING LOCOMOTIVES.

One of the notable advances made during the development of oil-engined locomotives for operation underground in British coal mines is the incorporation of complete Westinghouse air-brake equipment of both the straight and fully-automatic types; the fitting of the latter system is a requirement when the locomotive and train are to be used for transporting men. The erection and testing of the various valves, pipes and connections, however, is a lengthy operation, as generally these parts cannot be fitted until the locomotive is nearly completed. The subsequent testing of the air-brake system and rectification of any faults found during the tests frequently delay the final trials and, therefore, delivery of the completed locomotive. In order to reduce this time lag and at the same time simplify the assembly procedure, Messrs. The Hunslet Engine Company, Limited, Leeds, have designed both their 65 and 100 brake horse-power mining locomotives so that the complete Westinghouse braking equipment can be erected as a sub-assembly and subsequently lifted into or out of the locomotive as a single unit.

The main advantage gained by adopting this procedure is that the erection of the equipment and subsequent testing can be undertaken in any part of the factory and the complete unit subsequently fitted to the locomotive after approval. With a straight air brake only two connections are then required to be made, namely, to the brake cylinder and the compressor, with the possible addition of a further connection to the air-starting motor for the oil engine, should this item be fitted. With automatic braking equipment, however, four connections are needed, the two additional connections being for the train pipes.

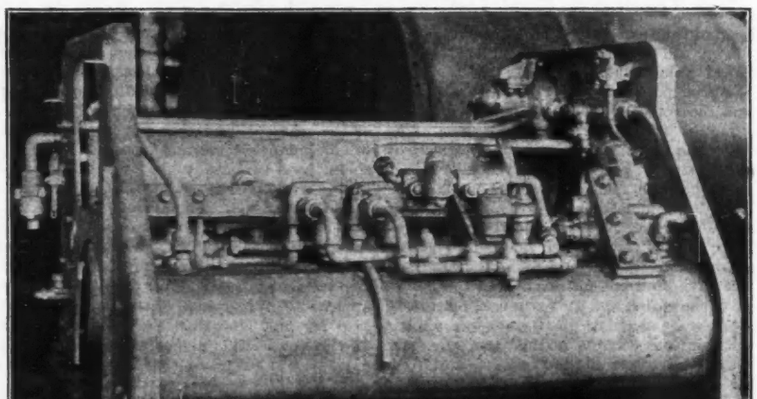
The complete air-brake sub-assembly for the 100-brake horse-power locomotives is illustrated on this page. The framework consists of two flanged steel end plates having a thickness of ⅝ in., the front plate being cut away to clear the locomotive main clutch while the rear plate acts as the cab weatherboard and consequently is formed with holes and cut-aways for the various gauges and operating levers. The two end plates, however, are not held apart by any structural members but by the cylindrical air-brake reservoirs which have tapped bosses formed on their ends to receive the set bolts that pass through the end plates; this form of construction will be apparent from the illustration. In addition to the braking equipment, the assembly includes the pneumatic whistle and the two-way sanding valve, while the weatherboard carries two air-brake gauges, the engine oil-pressure gauge, the speedometer, the electric tail lamp and two flameproof electric fuse boxes; the connections to the fuse boxes are made through a flameproof plug-and-socket type joint.

Fitting the various items of equipment into the framework presented some difficulty as the space was not all available for the purpose. It has been mentioned previously that the main clutch projects through the front plate but, in addition to this obstruction, the top of the locomotive gearbox projects into the bottom of the space formed by the framework, the fuel tank and the sand boxes occupy part of the top space, while the operating linkages for both the clutch and the gearbox also pass through the space.

Although the principal advantage gained from this form of construction is simplification of erection and final testing, other advantages follow as a matter of course. For instance, overhauling is eased considerably as it is a comparatively simple matter to remove the brake assembly as a complete unit and thus obtain access to the rear end of the locomotive. When this operation has to be carried out underground, the assembly can be removed with only 15 in. of headroom, the time required being about three hours; when working on the surface, however, this time is reduced to two hours. This form of construction also simplifies the dismantling of locomotives that have to be lowered down a pit shaft having a cage too small to take the complete engine. The most important feature, however, is that the complete Westinghouse unit can be removed from the locomotive and replaced without breaking and having to remake more pipe joints than those previously mentioned.

## AIR-BRAKE ASSEMBLY FOR MINING LOCOMOTIVES.

MESSRS. THE HUNSLET ENGINE COMPANY, LIMITED, LEEDS.



British Coal Output during 1947.—In reply to a question by Colonel L. C. Ropner in the House of Commons on Thursday, November 27, the Minister of Fuel and Power (the Rt. Hon. H. T. N. Gaitskell) said the coal output in this country during the 52 weeks ending December 27, 1947, was estimated to reach 196 million tons and 199 million tons during the 53 weeks ending January 3, 1948.

The Institution of Water Engineers.—The Anglo-Netherlands Society, in conjunction with the Institution of Water Engineers, Parliament Mansions, Victoria-street, London, S.W.1, have arranged for a lecture to be given by Dr. den Doolaard, who has made a special study of fen drainage problems, on the work accomplished in drying the inundated areas of Walcheren, Holland. It will take place at the Institution of Civil Engineers, Great George-street, London, S.W.1, on Tuesday, December 16, at 2.30 p.m. The Rt. Hon. Tom Williams, M.P., Minister of Agriculture and Fisheries, will occupy the chair.

# THE EARLY HISTORY OF PATENTS FOR INVENTION.*

By M. FRUMKIN.

(*Concluded from page* 511.)

IN 1537, one Bernard Swerts petitioned in Antwerp for a 20 years privilege for crystal glass. There is no trace of a patent granted to him, but in 1560 a Bernard Schwartz obtained from the Duke of Bavaria an authorisation to establish himself in that country on the condition that he should teach the Germans the secret of Venetian glass. In 1541, Cornachini seems to have had more success in Antwerp than Swerts or Schwartz, receiving privileges from the Emperor Charles V, always for glass. On the whole, the authorities did not foster inventions at that early period; in Bruges, for instance, the authors of some textile invention were simply forbidden to use it, and there were many similar cases. Such was the beginning in Antwerp, and nothing demonstrated better the role of the Italians than the fact that, out of the nine first patents found in the archives of Brussels by Doorman, six were granted to Italians. Among these Italians, for the third time we notice the name of Francois Berty, who here too, obtained, with a partner, a patent for making salt from seawater by a method they discovered.

It is not surprising that the overflow of the Antwerp patent system reached England. The two soapmakers who received the English patent listed No. I by Hulme came from Antwerp; and when, in 1567, Carre and Briet petitioned Cecil for a patent for glassware "à la façon de ceulx de Venize," their application referred to a similar privilege already obtained in Antwerp. Carre (or Quarre), who introduced a number of Murano glassworkers into England, then opened his works in London, at the Savoy House, in the Strand.

Applied to Antwerp patents, the term of "system" is fully justified. As early as 1551, de Lame, that early patentee, received a letter from Mary of Hungary, the "governess" of the Netherlands, asking him why, having received in 1549 a privilege for Venice glass, he did not work that patent. Still more remarkable is a letter from the Duke of Alba, a later governor of the Netherlands, addressed to the city of Liége, which city supported the request of the Prince-bishop of Liége for the exemption of one Francisci from the effects of a patent previously granted to one Pasquetti; the Prince-bishop wanted Alba to allow Francisci to sell objects, the manufacture of which was covered by Pasquetti's patent. Alba refused on July 12, 1569, stating the reason of his refusal: Pasquetti's grant was *un privilège octroyé passé longtemps par le Roy, mon maistre, à ung tiers au regard d'une invention nouvelle, avec défense generale, comme ordinairement se use par les princes en cas pareilz, que aultres ne puissent, pour le temps de son privilège, imiter son invention aux pays, ny, par imitacion extérieure, venir en iceulx le frustrer du fruict que le prince, par sa concession a voulu qu'il sente et recoibve en recompense et remunération de son labeur, et aussy des frais, dépens qu'il peult avoir mis en telle invencion et introduction d'icelle en son pays.* This letter, turned into modern language, would make an excellent first chapter to any patent-law manual of the Twentieth Century.

Holland had a flourishing patent system, which also started before 1550; in fact, there was an application for a system of royalties dated 1527, followed by an exclusive privilege in 1545. It seems that Dutch patents, though also ultimately of Italian descent, originated in the same way as German patents.

France, unlike Holland or Germany, follows the general rule, and patents appear in 1551, the middle of the Sixteenth Century being the normal date for the reception of the Italian institution. But these royal patents were preceded by a patent granted by the city of Amiens in 1543 for the invention of a calender or satin not requiring horses, but moved by one or two men. The city allowed Pierre Gestin and Robert de la Roche, the first French patentees, to use four round stones belonging to the corporation for weighting their machine. The first patent in the Kingdom of France was granted in 1551 to an Italian named Mutio for glass "*à la façon de Venise*," and represents a perfect model of an "importation patent"; while the second privilege, granted in the same year to Abel Foullon for a surveying instrument which he called "holometre," is no less typical of an invention patent proper. Foullon printed in 1555 a very detailed description of his holometre, in a book bearing the caption *par commandement et Privilège du Roi* on its title page. In 1558, the same Foullon received a patent for a horseless carriage. Over 100 years later, the need for a detailed specification was felt again, witness the patent to Perrot (1688), which contained the following passage: "that new invention . . . seems so extraordinary that it appears that it will not be understood if stated in general terms, and that it will be necessary to make of it a special and precise statement order to deprive those would like to trouble the said petitioner in the use of his privilege of all pretext to do so."

Examination and experiments to that effect were a standing practice in France; so, for instance, in 1609, Le Caire and Thouyn both petitioned for patent protection for the furnaces they claimed to have invented. A practical examination in the presence of the minister Sully himself was imposed in order to decide between these contradictory claims. Some of the early French patents seem to correspond to contemporary English grants; thus the French patent of 1596 for the conversion of iron into steel was perhaps granted to the same French partners who petitioned Queen Elizabeth for a similar subject. Incidentally, that patent did not involve monopoly rights, but a system of licences with royalty collectors specially appointed at each furnace where the patented method was to be used. Another French privilege, issued in 1601, seems to correspond to the English "New Art" patent. Very quickly, the number of French patents began to increase, and it is quite possible that France granted more protection rights for invention than any other country, perhaps even more than all the rest of Europe. But that enormous output of patents in France carried with it, together with many excellent things, a great weakness; unlike England, there was no legal basis to it, and no continuity.

While the idea of granting exclusive right for inventions was brought in the middle of the Sixteenth Century to England, France and Antwerp by Italians, many of whom were glassworkers, the same idea reached Germany at an earlier date and in a different manner. The reason for that was that "with certain exceptions Venetians were actually prohibited from travelling to Germany to sell their own goods or to buy German products. Such transactions were all to take place in Venice." The Germans had a house in Venice, the Fondaco dei Tedeschi, where they learned Italian business methods. The Germans of the Fondaco, returning to their country, brought with them the idea of invention patents. In addition to that, there were some Italians in Germany who also played a certain role in this respect, but their influence was not decisive, as in Antwerp or in England. So the very early Saxon patent of 1484 for the draining of mines was granted to Blasius Dalmaticus, of the Venetian city of Ragusa, ten years after the Venetian patent law was enacted. The subsequent German patents were also granted by the Elector of Saxony, in 1502 and 1512; but already in 1469 a German had received a Venetian patent. This disposes of the assertion, expressed by some German authors, of German priority, an assertion which is based on two facts of very dissimilar nature: the really very early date of the first German patents, and their own ignorance of the still earlier Venetian system.

Even some petty princes had granted patents before 1550; the Margrave of Brandenburg-Onolzbach, in 1535, being then the owner of the district of Tarnowice, in Silesia, granted there an eight years' monopoly for a pump to be used in mines. Saxony continued to grant patents in the second half of the Fifteenth Century. In Bavaria, there was, in 1596, a patent for glass granted to two Italians, and later privileges were granted by the cities of Augsburg and Nuremberg. The Emperor Charles V himself was interested in "gadgets," and granted patents willingly. Meldau discovered a broadsheet or advertisement for a patent of 1545, and in 1610 one Hayden, who invented the "clavicembalo," printed a description of that new music instrument, for which he asked and obtained an imperial patent three years later. In 1664, another imperial patent was granted for a quick-firing rifle, of which there was also a printed description, but so far it has not been possible to ascertain whether there was a definite connection between that grant and the description. At that time, the German system, like the Italian, was in full decay, almost extinct. During the Eighteenth Century, the number of patents declined further, and Meldau could not find more than four for the period 1750-1800.

Austrian authors believe that the earliest patent issued in the hereditary possessions of the Hapsburgs was the privilege of 1560 granted by Ferdinand I for a method of saving fuel; but, in 1534, a 20 years' privilege was granted to Wolfgang Vitl, who introduced glassworkers from Italy to the Inn Valley. Vitl was hindered in his industry by the lack of potash, which led him to invent a new method for the extraction of that ingredient for glassmaking from vegetable ash, an invention for which he obtained a patent in 1546. In Austria, too, the number of patents diminished rapidly during the Seventeenth Century, and during the Eighteenth they became almost extinct.

In Poland, the King, Stefan Batory, granted, in 1578, a patent to the brothers Hans and Caspar Goebel for a coining press—at that time coins were still manufactured by hammering by hand. A print relating to the grant is known, but its nature has not been ascertained. In Switzerland, the canton of Berne assured Anton Jacki, in 1467, that no other paper mill but his would be allowed on Bernese territory; Jacki also received an exclusive right to trade with rags. A real invention patent was granted in 1577 by the canton of Zürich for saltmaking, but from then on it seems that there were no more Swiss patents; and in 1730 the Government of Zürich refused an application on the grounds that monopolies did not suit a republic and that, if the privilege were granted, every burgess who made an invention would have the right to a similar privilege. In Russia, Lomonosov's monopoly for glass beads, of 1752, has long been considered as the first patent, but actually, in 1634, the Tsar Michael gave the Swede Koet a 15 years' privilege for glass.

The great invention of printing caused the appearance of many grants; some of them were patentlike, but the majority were nothing else but the first registered designs, or design patents. The impulse was given in 1469 by Venice, where the German printer, Johann von Speyer ("Giovanni da Spira") received a patent for the art of printing. The first design patents followed in about 30 years' time, the most important of them being the privilege protecting the newly-invented italic type of Aldus, the famous printer of Venice. The example of Venice was followed by France, where, in 1558, the printer Granjon, creator of the "*lettre de civilité*," printed in that type a poem by Gautier de Lille, the "Alexandreidos," not forgetting to print the text of his ten years' privilege at the beginning of the volume. The secretary who signed the extract was Jean Nicot, of tobacco fame.

In England, William Byrd, the Elizabethan composer, received a monopoly for the printing of music and paper ruled for music; while Timothy Bright received an exclusive right to use his signs ("characterie"), sometimes called a shorthand system, for the printing of books. It is necessary also to mention the Scottish privilege of 1507; Chapman and Millar, the first printers in Scotland, were rewarded with a monopoly for printing certain classes of books. Early privileges for printing type of a new shape are also known in Germany.

Antwerp, which succeeded Venice as the foremost place in European economy, soon lost its supremacy to London and Amsterdam; but, owing to the existence of the Statute of Monopolies, it was England and not Holland which took over the role of Venice and became a model for other countries as far as patents were concerned. The English colonies in America adopted English principles at an early date and without difficulty. They even inherited the English fear of monopolies, and the 1641 decree of Massachussets reads like a second edition of the English law of 1624: "there shall be no monopolies granted or allowed among us, but of such new inventions as are profitable to the country, and that for a short time." South Carolina, in a law of 1784, fixed at 14 years the term for which inventors' privileges could be granted. Later, the constitutions of Maryland and Texas still maintained provisions against monopolies.

On the Continent of Europe, all countries received from France the idea of legislation affecting patents, and that at a fairly late date, after the outbreak of the French Revolution; but France itself, though leading by the number of patents granted, was inspired by the example of England. The earliest English patent in France seems to have been that "Humfrey Bradleij," who, in 1599, received a 15 years patent for his methods, tools, machines, practice, etc., used for drying fens. In 1607, "in order to give more courage to the said contractors"—Bradley and his partners—they were promised nobility titles by Henry IV of France.

The application for a patent lodged in 1727 by "Elias Barnetz," also an Englishman, for two textile machines of his invention illustrates a fairly common French practice of that time; the patent was refused, but the inventor received a pension of 100 francs. On the other hand, Kay received a French patent for his flying shuttle in 1747. In 1784, Mayor Oppenheim, of Birmingham, was granted a patent for a method of glassmaking; that privilege was of a somewhat archaic character, being valid only within a radius of 10 leagues around Rouen. In 1789, one Ducrest applied for a French patent, stating that he had already taken out an English patent for the same invention. The Bureau de Commerce (the French equivalent of the English Board of Trade) decided then to study the English law in this connection. The public authorities were already preceded in this way by the Chamber of Commerce of Normandy, which already, in 1787, had published Observations on the Trade Treaty between France and England, extolling the English patent law and proposing similar legislation in France. The Revolution came, and patents for invention were discarded as "odious privileges"; however, in 1791, a group of dissatisfied inventors petitioned the National Assembly, asking for the issue of a patent law and presenting memoranda on the English patent system. The French patent law, soon imitated by all other Continental States, was enacted in the same year.

* Paper presented at a joint meeting of the Chartered Institute of Patent Agents and the Newcomen Society, held in London on November 12, 1947. Abridged.

# ALTERNATING-CURRENT NETWORK ANALYSER.

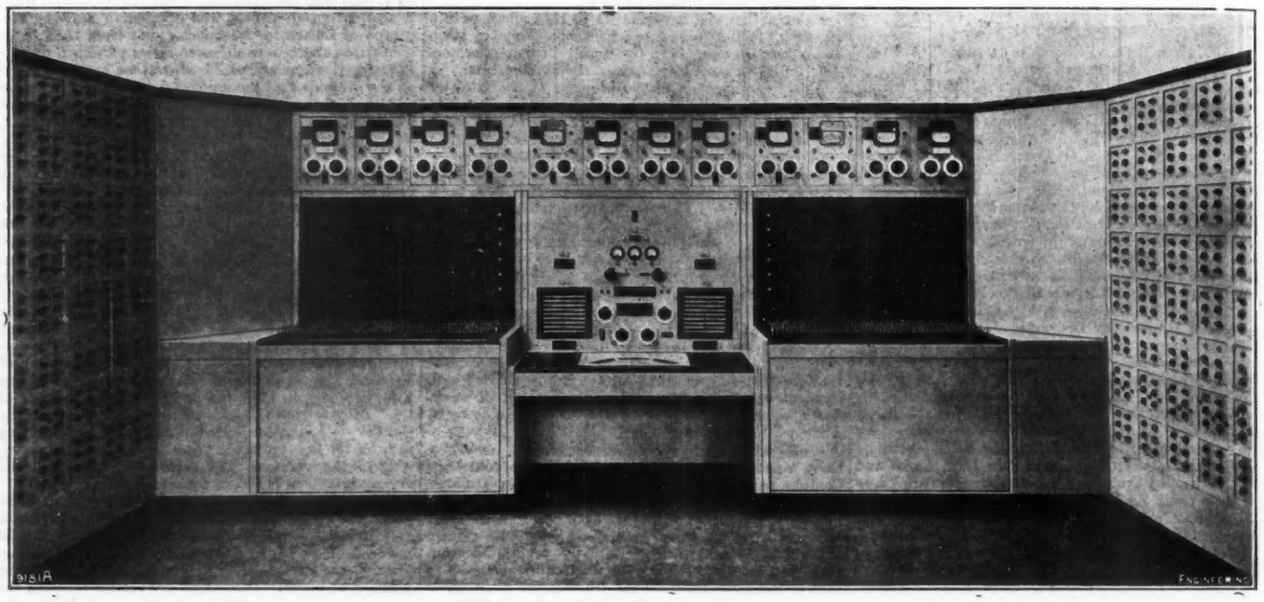


FIG. 1. GENERAL VIEW OF ANALYSER.

## ALTERNATING-CURRENT NETWORK ANALYSER.

A KNOWLEDGE of the behaviour of an electrical power system under different operating conditions, both normal and abnormal, is of importance not only to the engineer who is concerned with the maintenance of the supply, but to the designer of the plant, particularly of the switchgear that is employed. This applies not only when a new scheme is being considered, but also, perhaps, with more force, when an alteration, such as an increase in generating capacity or an extension of the transmission system, is being worked out. To determine this behaviour, it is necessary to assess such factors as the distribution of current, voltage and real and reactive power in the network, and, although this task can be performed mathematically, the calculations frequently become so protracted and laborious that an accurate solution is impracticable. By the use of a special arrangement of miniature variable resistors, reactors, capacitors and transformers, together with voltage sources which are also variable in magnitude and phase, the actual conditions that will arise in practice can, however, be simulated. The characteristics of the equivalent full-scale system can then be evaluated by direct measurement; and the effects of changes can be predicted accurately in a fraction of the time required for normal calculations. Such a system, which is known as a network analyser, also provides a means of obtaining practical solutions to many problems, such as what occurs on a network under fault conditions, which would otherwise not be undertaken simply because the amount of work and time required to arrive at a satisfactory quantitative solution would be prohibitive.

Up to the present, an alternating-current network analyser has not been available for general use in this country, although its utility for dealing with a wide range of electrical and other problems has been recognised. Some time before the war, it was, in fact, decided to put the necessary construction in hand, but the project had to be given up in favour of more urgent activities. It is therefore satisfactory to be able to record that an instrument of this kind has now been installed at the Willesden works of one of the constituent companies of Associated Electrical Industries, Limited, Crown House, Aldwych, London, W.C.2, this site having been chosen mainly because it is within easy reach of Central London. This network analyser, which will be available for use by accredited representatives of British engineering concerns, is housed in a spacious well-lighted room adjacent to a suite of offices where the preparation and collation of the preliminary data on any problem can be effected expeditiously and where the necessary records can be kept and confereuces may be held.

The general appearance of the analyser at Willesden will be clear from Fig. 1, which shows the desk from

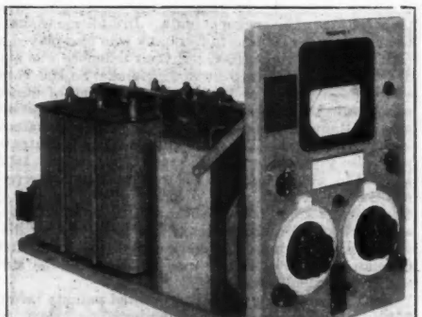


FIG. 2. GENERATOR UNIT.

which the metering circuits and the majority of the supply circuits are controlled. The analyser is supplied with three-phase current at 50 volts and a frequency of 500 cycles per second from a motor-generator set, the output of which is delivered to 'bus-bars in the cubicle shown in Fig. 3, opposite. The voltage of the generator of this set can be varied by contactors and the selected value can then be maintained constant to within $\pm$ 0·2 per cent. by an electronic regulator. The synchronous motor of the motor-generator set is normally connected to the 50-cycle mains. An alternative supply, however, can be obtained from a three-phase 50-cycle generator should the frequency of the works supply vary unduly. This generator is driven by a direct-current motor, the speed of which can also be electronically controlled within $\pm$ 0·2 per cent. A frequency of 500 cycles has been chosen in order to reduce the size and weight of the various components used in the analyser. For the same reason, the nominal voltage and current values of 50 volts and 50 milli-amperes have been adopted as basic quantities. It has been possible, therefore, to use telephone-type apparatus for interconnection and switching.

Twelve generator units, which can be seen at the top of Fig. 1, are housed above the three central panels of the analyser; one of the units is shown in greater detail in Fig. 2. Each of these units, which are used to simulate either a single alternator or a complete power station on a system, consists essentially of a phase-shifting transformer, which is built on the frame of a wound induction motor. This motor has a two-pole three-phase delta-connected rotor, which is fed from the 500-cycle supply. The voltage of this unit can also be adjusted in magnitude, a multi-range watt/var meter being provided to assist in setting the dials of the controls. Additional phase-angle control is effected from the 500-cycle three-phase 'bus-bars. On the secondary side, the output of each generator unit is of constant magnitude, although the phase difference can be varied through an angle of 360 deg. This output is passed to a magnitude control device, which enables adjustments to be made over a range from zero to 285 per cent. without an appreciable change in phase. The reactance of the two controls is compensated so that the required regulation of the load is negligible. It is thus possible to obtain twelve voltage sources on the analyser. Each of these sources can then be varied from zero to 285 per cent. within a tolerance of $\pm$ 1 per cent., and set to any phase-angle relative to a chosen reference.

The load on the system and the conditions on the line are simulated by 30-load and 120-line impedance units. These units comprise banks of reactors and non-inductive resistors, the value of which can be varied by means of selector switches. The resistance/reactance ratio of the reactors is on the average as low as 1 to 33. The line units cover low ranges of impedance and are used to represent series circuit elements. The ranges of impedance of the load units are, however, much higher, so that they can be employed as shunt elements or as series elements of high value, such as would be required to represent, for example, a long overhead line. Similarly, the capacitor units, of which there are 60, are used to represent the capacity of long lines, cables and other apparatus. These units each consist of banks of tapped capacitors, of values that allow the percentage susceptance to be read directly on the scales of the selector switches. These capacitor units can also be used in place of the generator units to represent small synchronous condensers. Further, there are 36 auto-transformer units, each of which has a range of $\pm$30 per cent. in 1 per cent. steps. These auto-transformers can be used for a number of purposes; for example, in conjunction with a load unit, to represent a load in situations where the voltage may vary; to simulate differential tap selection on transformers in parallel; and, in conjunction with capacitor units, to represent the capacities of large systems. Finally, there are twelve 1 to 1, two 2 to 1, and two $\sqrt{3}$ to 1 coupling transformers. These are employed to represent the effect of mutual coupling between circuits, such as is necessary in setting up problems for solution by the symmetrical and related component methods which are commonly used in network analysis. All these units, which, together, form the circuit elements, are housed in the cubicles which, as can be seen in Fig. 1, form the wings of the analyser and are connected to plugs on each side of the control desk. The desired interconnection between the generator, load and other units is effected by inserting the corresponding plugs in the appropriate jacks, which are arranged on the panels above the plugs on each side of the central position. A view

# ALTERNATING-CURRENT NETWORK ANALYSER.

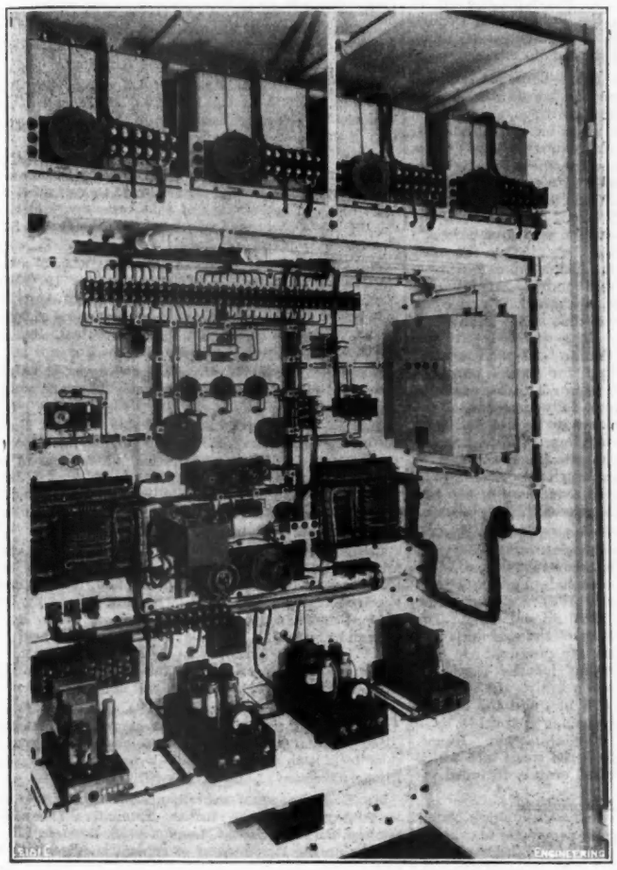


FIG. 3. REAR VIEW OF CENTRAL CONTROL CUBICLE.

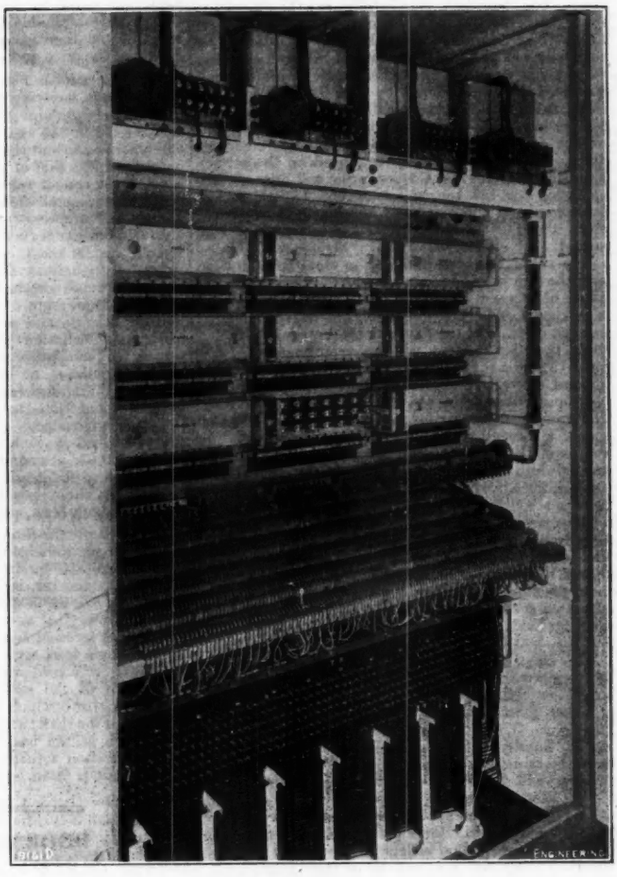


FIG. 4. REAR VIEW OF PLUGGING CUBICLE.

of the rear of the central control cubicle is given in Fig. 3, and of one of the plugging cubicles in Fig. 4. The control of the motor-generator sets and generator units is effected by normal indicating instruments which are visible in Fig. 1. To meter the circuits set up by the various load, line and other elements, three master instruments, a voltmeter, ammeter and watt/var meter are provided. These are all operated by negative feed-back valve amplifiers, so that the burden on the circuit into which they are inserted is negligible. Multiple ranges are obtained by suitable current shunts and voltage dividers. Each unit, except the generator units and the coupling transformers, has a telephone relay in its plug connection. The coils of these relays, banks of which are visible in Fig. 4, are wired to jacks on a selector board on the control panel, and are energised by the insertion of a dummy plug in the appropriate jack. In this way, the unit is connected to the 'bus-bars, which form part of the metering system, so that the necessary reading can be taken. It is claimed that this system has the advantages over the use of telephone key switches, in which all the leads must be brought to the control desk, that stray capacity in the leads is reduced and that it is impossible accidentally to select two units simultaneously, a mistake which might result in "sneak" currents and damage due to short circuits.

The master instrument system used for these measurements has an overall accuracy to within $\pm 0{\cdot}5$ per cent. The maximum error probable in any set up is $\pm 2$ per cent., and will generally be less. Nevertheless, it must be appreciated that the accuracy of the results obtained from the analyser can never be better than the accuracy of the system upon which the studies are based. It is essential, therefore, that whenever possible exact information regarding the impedances of machines, transformers, reactors, earthing devices, overhead lines, cables and other apparatus should be available. For some types of investigations it is necessary also to know the operating characteristics of the voltage regulators and the inertia constants of the rotating plant. It should also be pointed out that the network analyser has certain fundamental limitations. It is primarily confined to a single frequency, so that when, for example, harmonic problems are being considered, the appropriate network must be separately analysed for each frequency. Moreover, it is a "steady state" device and can therefore only be applied to the solution of transient stability problems by step-by-step methods. Finally, it cannot be used to solve problems for which no theory of solution is known.

The operation of the analyser may be briefly described as follows: a diagram of the system is prepared on the drawing board and on this diagram the data relating to the system constants are noted and subsequently collated. The aggregate load on the system is then converted to a suitable base, which is stated as a percentage of the original. To some extent, the selection of the actual base chosen is arbitrary, although experience is a guide and it is naturally desirable that the value chosen should be such that suitable readings can be obtained on the instruments. All the constants are then converted to this percentage basis and from the values thus obtained plugging charts are prepared, from which the analyser is set up, as described above. After the analyser has been energised and the necessary adjustments have been made in accordance with the specified conditions, the voltages, currents and other quantities can be read off on the instruments. Finally, the readings thus obtained are converted into system quantities by the use of appropriate factors; and the results are used to solve the particular problem being considered. It will be seen, therefore, that the object of the analyser is to save time and obtain greater accuracy by the elimination of laborious calculations. As an indication of its scope, it may be noted that the types of problem to which the analyser may be usefully applied include investigations of systems operating both normally and under fault conditions; problems relating to stabilities, apparatus and the circuits themselves can also be studied. Typical examples of the first class of problem are the division of the load in watts and vars, 'bus-bar voltages, transformer ratings and the effects of alterations to the network and of reactors and load variations. The analyses of systems under fault conditions include such questions as the maximum short-circuit duty for circuit-breaker applications, and maximum and minimum fault currents and voltages for protective-gear applications. Among possible studies of stability, mention may be made of investigations into the transient limits for various types of fault and the effect of high-speed re-closing, while apparatus and circuit problems include a consideration of the best methods of starting large synchronous motors. Finally, it is claimed that the analyser can be used to deal with mechanical, thermal and other non-electrical problems which can be represented by electrical equivalents. These include the vibration of shafts and the determination of heat flow in complex bodies.

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FILM OF IRON AND STEEL WORKS.—A film of the Ebbw Vale works of Messrs. Richard Thomas and Baldwins, Limited, has been made, and is to be shown to the employees of the firm in order that all may be acquainted with the scope of the organisation to which they belong. We have been given an opportunity of seeing the film, which runs for 47 minutes and shows the works marshalling yards, coke ovens, blast furnaces, basic Bessemer and open-hearth melting shops, the hot strip-rolling mill, the cold-rolling mill, the Melingriffith tinning plant, the electrolytic tinning installation, and the packing and dispatch of finished tin-plate.

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WATER POWER RESOURCES OF THE UNITED KINGDOM.—In reply to a written question by Mr. F. Byers in the House of Commons on November 27, the Minister of Fuel and Power (the Rt. Hon. H. T. N. Gaitskell) said that the generating capacity now in course of development for utilising water power in the United Kingdom was 400 MW. The estimated cost of construction was 19,000,000*l.*, and the estimated average annual output 802 million kWh. Additional capacity, estimated at 400 MW, had been surveyed, but was not yet being developed. It was estimated that the Severn Barrage Scheme would cost 47,000,000*l.* (at 1944 prices) and would have an average annual output of 2,000 million kWh.

## LAUNCH OF S.S. "COMMANDANT QUERÉ".

THE passenger and cargo steamer Commandant Queré was launched successfully at the Woolston shipyards of Messrs. John I. Thornycroft and Company, Limited, on Saturday, November 29. The launching ceremony was performed by Madame Albert Lellouche, wife of l'Ingénieur Général Lellouche, of the French Merchant Navy. Ordered by the French Merchant Navy Administration on behalf of the Compagnie de Navigation Fraissinet, the Commandant Queré will replace one of the many ships lost by this company during the war, and will be employed on the service between Marseilles and Corsica. She will have accommodation for 158 tourist passengers, 134 third-class passengers and approximately 700 fourth-class passengers; in addition, about 1,000 tons of cargo will be carried.

The vessel has been designed in close collaboration with the owners so as to ensure that the special requirements of this service will be met; the designed speed is 18 knots. The length overall is 363 ft., the moulded breadth 50 ft., and the depth to the upper deck 28 ft., while the displacement will be approximately 4,400 tons. There are five decks, the lower deck extending forward and aft from the machinery space while the main and upper decks run the full length of the ship. The promenade deck runs from the stern to the after end of a forward well and the boat deck extends for approximately half the vessel's length. The hull is divided into ten main compartments by nine watertight bulkheads,which terminate at the main deck and there is a continuous double bottom which is arranged for the carriage of fresh water and fuel oil. In addition, deep fresh-water tanks are situated forward and aft, while deep oil-fuel tanks are located between the forward end of the boiler room and No. 2 hold. Altogether, there are three holds, two forward and one aft, and refrigerated spaces will be provided at the forward end of the after hold. The holds will be served by two 7-ton derricks, four 5-ton derricks and one 15-ton derrick.

The vessel will be engined by Parsons-type steam turbines arranged to drive twin screws through double-helical reduction gearing, and giving a maximum of 5,400 shaft horse-power at a propeller speed of 210 r.p.m. The turbines are being manufactured by Messrs. Thornycroft. The high-pressure turbines will be of the impulse-reaction type, while the low-pressure turbines will be fitted with reaction blading only; in addition, a three-row astern impulse turbine will be fitted at the exhaust end of each low-pressure turbine and these will develop about 40 per cent. of the full-ahead power. The boilers also are being built by Messrs. Thornycroft and will be of their single-sided, three-drum water-tube type. One side and parts of the back and front of each boiler consist of radiant-heat tubes only, while the remaining side in each case contains the main generating tubes and superheaters. The superheaters have been designed to give a steam temperature of approximately 600 deg. F., and are of the Thornycroft straight-through type. The boilers will be oil fired on the pressure-jet system and will be arranged to work in a closed stokehold, to which air will be supplied by two Keith Blackman motor, driven forced-draught fans. The closed-feed system developed by Messrs. G. and J. Weir Limited, will be fitted and, in addition to the two turbo feed pumps associated with this system, an auxiliary feed pump of the double-acting reciprocating type will be provided. Steam for the vessel's heating services, etc., however, will be provided by a Spanner thimble-tube boiler which will be located in the boiler room. The main condensers will be of Messrs. Weir's regenerative type and this firm are also supplying the evaporating equipment.

The auxiliaries associated with the main-propulsion units will be largely of the motor-driven type, and the current for this purpose will be provided by three 175-kW Diesel sets, the engines of which will be supplied by Messrs. Mirrlees, Bickerton and Day, Limited, and the generators by Messrs. W. H. Allen, Sons and Company Limited. In addition, a 25-kW Diesel set will be fitted on the boat deck for emergency use.

As previously mentioned, the Commandant Queré will be fitted out to carry three classes of passengers. The tourist dining saloon will be on the upper deck and will provide accommodation for 100 passengers at a sitting. From a vestibule adjoining the dining saloon, stairways will lead downwards to the tourist cabins on the main deck and upwards to the smoking room and bar on the promenade deck, which also will accommodate further tourist-class cabins. The third-class accommodation will be arranged forward on the main and upper decks; the dining room, lounge and bar, together with some of the cabins, will be on the upper deck, while the remainder of the cabins will be on the main deck. Fourth-class passengers will be carried aft and will not be provided with berths. Accommodation for the crew will be arranged amidships on the main and upper decks, and that for the officers in a deck-house on the boat deck.

## BRITISH STANDARD SPECIFICATIONS.

THE following specifications of engineering interest have been issued by the British Standards Institution. Copies are obtainable from the Publications Department of the Institution, 28, Victoria-street, London, S.W.1, at the price quoted at the end of each paragraph.

*Copper and Brass Tubes for Gas.*—Three newly-issued specifications, covering copper and brass tubes for gas-installation work and gas-lighting fittings, are based on B.S. Nos. 659, 885 and 886, which have been adapted and amended to suit the special requirements of the gas industry. The first of the new specifications, B.S. No. 1401, is for copper tubes, plain or screwed as may be required, for installation work and also for gas-lighting fittings. The second specification, B.S. 1402, is for annealed brass tubes for installation work, and normally screwed, while the third, B.S. No. 1403, is for brass tubes for gas-lighting fittings. These tubes, which are normally supplied in the screwed condition, are intended for the manufacture of pendants, brackets and other lighting fittings, and are somewhat stiffer than those used for installation work. It is pointed out that tubing for installation work has to withstand bending and manipulation at the site; for special purposes, where maximum flexibility is required, as, for example, in bent connections to meters, fully-annealed copper tubing is advocated. Tolerances as to size and tests are prescribed in each specification. In the case of B.S. No. 1403, a mercurous nitrate immersion test to ascertain any liability to cracking is specified. [The price of the three specifications, bound up in one and the same cover, is 2*s.*, postage included.]

*Rotary-Shaft Oil-Seal Units.*—A new specification deals with the dimensions relating to rotary-shaft oil-seal units suitable for fitting into housings from 0·75 in. to 8·0 in. diameter, and accommodating shafts from 0·25 in. to 7·0 in. in diameter. It covers single wide, single narrow, dual and semi-dual oil-seal units. The form of the internal construction of the seal units and the materials from which they are produced are controlled to a considerable extent by the particular application of the seal. Consequently, the bore of the housing into which the seal fits, and the outside diameter of the shaft, which the sealing lip touches, have been taken as the basis for standardisation. Hence, the specification actually defines the space into which the seal unit is fitted. [Price 2*s.*, postage included.]

## BOOKS RECEIVED.

*Electricity Commission. Electricity Supply*, 1943-44. *Return of Engineering and Financial Statistics Relating to Authorised Undertakings in Great Britain for the Year* 1943-44. H.M. Stationery Office, Kingsway, London, W.C.2. [Price 21*s.* net.]

*Ministry of Supply. Second and Final Report of the Committee of Investigation into the Cotton Textile Machinery Industry.* H.M. Stationery Office, Kingsway, London, W.C.2. [Price 4*d.* net.]

*Ministry of Transport. Railway Accidents. Report on the Collision which Occurred on the 17th September*, 1947, *at Burton Agnes Level Crossing on the London and North Eastern Railway.* H.M. Stationery Office, Kingsway, London, W.C.2. [Price 2*d.* net.]

*Chimie organique.* Volume I. *Chimie organique générale.* Volume II. *Fonctions simples.* By PROFESSOR A. KIRRMANN. Librairie Armand Colin, 103, Boulevard Saint-Michel, Paris (Ve). [Price 100 francs each volume.]

*Industry in Sussex. A Record of the Industrial Actualities and Potentialities of the County.* Compiled and Published by the Sussex Engineers and Manufacturers Association, Limited, 3, Marlborough-place, Brighton. [Price 5*s.* net.]

*The British Electrical and Allied Manufacturers' Association (Inc.).* Publication No. 135. *British Electrode Classification. Covering Manual Arc Welding Electrodes for Welding Mild Steels.* Prepared and issued in collaboration with the Institute of Welding. Offices of the Association, 36-38, Kingsway, London, W.C.2. [Price 1*s.* net.]

*Industrial Electrification. A Handbook for Electrical Engineers Employed in the Installation, Supervision and Maintenance of Electrical Plant in Industrial Undertakings.* By J. W. MCQUILLEN. Sir Isaac Pitman and Sons, Limited, Parker-street, Kingsway, London, W.C.2. [Price 12*s.* 6*d.* net.]

*Practical Design of Simple Steel Structures.* Volume I. *Shop Practice, Riveted Connections and Beams, etc. With an Appendix of Tables (Formerly Volume III).* By DR. DAVID S. STEWART. Third edition. Constable and Company, Limited, 10, Orange-street, London, W.C.2. [Price 15*s.* net.]

*Department of Scientific and Industrial Research. Road Research.* Road Note No. 2. *Chemical Treatments for Icy Roads.* H.M. Stationery Office, Kingsway, London, W.C.2. [Price 3*d.* net.]

## PERSONAL.

MR. E. K. DAVIS, director and President of Aluminium Limited, Montreal, Canada, since the organisation of the company in 1928, has retired, and has been succeeded in these offices by MR. N. V. DAVIS, who is at present managing director of Messrs. Stand Limited, 11, Bruton-street, London, W.1, and in charge of the interests of Aluminium, Limited, in the United Kingdom.

DR. C. H. DESCH, F.R.S., and LT.-COL. SIR JOHN GREENLY, K.C.M.G., C.B.E., M.A., M.I.Mech.E., have been elected Fellows of the Institute of Metals in recognition of their eminent services to the Institute.

ENGINEER REAR-ADMIRAL C. W. LAMBERT, C.B., M.I.Mech.E., chief engineer of the Appleby-Frodingham Steel Company, Limited, Scunthorpe, Lincolnshire, has been appointed a director of that company, which, as our readers are aware, is associated with the United Steel Companies, Limited, Sheffield.

ENGINEER CAPTAIN J. C. BRAND, R.A.N. (ret.), M.I.Mech.E., M.I.N.A., M.I.Mar.E., late Inspecting Engineer, London, for the Commonwealth of Australia, is in practice as a consulting engineer and naval architect at 28, Waratah House, 47, Bayswater-road, Sydney, Australia.

MR. F. R. E. DAVIS, C.B.E., secretary of the Great Western Railway Company for nearly 22 years, retired on November 30.

MR. H. LANDSTAD, the designer of the first Morris motor-car engine and one of the original directors of Morris Motors, Limited, has retired at the age of 67, after 33 years' service with the Nuffield Organisation. MR. R. F. HANKS, previously managing director of Nuffield Exports, Limited, has been made vice-chairman of the Nuffield Organisation.

Consequent upon the retirement of MR. H. N. BATES, MR. C. F. RUSSELL has been elected chairman and managing director of Specialloid, Limited, North Finchley, London, N.12. MR. L. H. MAIDMAN, secretary; MR. H. R. PETERS, general sales manager; and MR. R. A. CUTHBERT, general works manager, have joined the board. MR. E. S. BAILEY has been elected vice-president of the board of Specialloid (Canada), Limited, and MR. G. C. DOWNING, director and general manager.

MR. J. K. REDMAN, A.R.C.Sc., B.Sc. (Lond.), A.F.R.Ae.S., formerly of the technical department, Gloster Aircraft Company, Limited, has been appointed chief technician in the aircraft division of the Dunlop Rubber Company, Limited, Foleshill, Coventry.

MR. E. A. LANGHAM has relinquished his appointment as sales manager, the British Aluminium Company, Limited, Salisbury House, London Wall, London, E.C.2 to take up the appointment of general manager for the British Aluminium Company, Limited, in India. MR. A. W. LANGHAM, manager of the sales planning department, will, for the present, undertake responsibility for the sales department in addition.

MR. S. HALLIDAY, F.R.S.A., formerly on the sales staff of the Portsmouth and Gosport Gas Company, has been appointed technical sales representative of Messrs. Parkinson and Cowan (Gas Meters), Limited, Terminal House, Grosvenor Gardens, London, S.W.1, in connection with infra-red heating equipment manufactured at the firm's Cottage Lane Works, City-road, London, E.C.1.

MR. J. H. METTRICK has succeeded the late MR. J. L. LOE as representative of Messrs. E. Boydell and Company, Limited, manufacturers of Muir-Hill equipment, Elsinore-road, Old Trafford, Manchester, 16, in the North-East of England.

MR. A. E. TAYLOR, M.B.E., representative of Messrs. Edgar Allen and Company, Limited, Sheffield, 9, in the East Midlands Area, is retiring on December 31. He will be succeeded by MR. GILBERT FRANCIS.

MR. WILLIAM WOOD, general manager of Messrs. Thos. W. Ward (Coal), Longbottom, Limited, Harvest-lane, Sheffield, has been appointed assistant managing director. MR. S. J. DYAL has been appointed a director of Messrs. Thos. W. Ward Limited, Albion Works, Sheffield. He has served the firm as chief valuer for many years.

MESSRS. THE GRANTHAM BOILER AND CRANK COMPANY, LIMITED, Grantham, Lincolnshire, inform us that their London office is being changed from 17, Victoria-street, to 36-38, Whitefriars-street, London, E.C.4.

MESSRS. GANDY LIMITED, Wallasey, Cheshire, are removing their Manchester office and warehouse to new and more suitable premises at 4, Wood-street, Deansgate, Manchester, 3, as from December 15.

MESSRS. CROFTS (ENGINEERS), LIMITED, Empire Works, Thornbury, Bradford, have purchased the whole of the assets of MESSRS. NEWTON, BEAN AND MITCHELL, Dudley Hill, Bradford. After reorganisation and re-equipment, Messrs. Crofts intend to move certain of their manufactures to Dudley Hill, with a consequent large increase in the number of employees.

The Board of Trade announce that the address of the DIRECTORATE OF MICA is now 23, Buckingham-gate, London, S W.1. (Telephone: VICtoria 7503.)

## NOTES FROM THE NORTH.

GLASGOW, Wednesday.

*Scottish Steel.*—Production at the steelworks has continued at the recent high levels, and there are strong indications that these will be maintained until the New Year holiday. Fuel supplies have been on a much improved scale, and there are signs that additional quantities of coke may be available to justify lighting up additional blast-furnaces early in 1948. The principal shortage hindering production is the continuing reduced supply of semies. Re-rollers are not obtaining full production owing to insufficient supplies of bars and sheets. There is a growing consensus of opinion here in favour of a policy of importing semies from Germany. The conclusion of the Anglo-Swedish agreement has been received with widespread interest in Scottish iron and steel circles, and the general feeling is that there will be a special allocation of steel products in return for increased imports from Sweden of ore, timber, and other essential commodities.

*Scottish Coal.*—The recent satisfactory performance by Scottish miners was marred by an outbreak of strikes in the West, resulting in a loss of over 7,500 tons, or about 2,500 tons a day. The strike arose from dissatisfaction among pieceworkers, who were demanding an increase in pay corresponding with the recent increase to oncost workers. Outputs from the unaffected collieries were at the high level current for four or five weeks now. All types of users were in receipt of tonnages at or slightly above their full allocations. Consumption was below deliveries in many cases, so that further stocks were secured. Lord Balfour's recent mention of the possibility of a resumption of coal exports in the near future on a much larger scale than hitherto, provided the miners continue to put up their present performances, has invigorated a listless export market. Coastwise traffics to Northern Ireland and the South Coast were heavier, but difficulties occurred in securing suitable shipping.

## NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

*General Situation.*—Iron and steel producers have embarrassingly heavy arrears of deliveries, but changing conditions encourage the hope that the position will permit expansion of business in the near future. Tonnage distribution is on an improved scale but is still hampered by wagon shortage, and the importance of the quickest possible turn-round of trucks at works is emphasised by a circular issued by the Tees-side Chamber of Commerce, in which it is pointed out that wagons should not be used as warehouses but that inward loaded trucks should be emptied quickly and sent back to the railway company or loaded outward without delay. The demand for larger supplies of nearly all descriptions of iron and steel continues and better fuel deliveries are permitting increased outputs of furnaces and foundries to be made. The record makes, however, still lag behind the ever-expanding demand. The output of the Cleveland ironstone mines continues to be disappointing and there are still frequent complaints about the inconvenient shortage of iron and steel scrap. Pig-iron is still needed in larger quantities than are obtainable; manufacturers of semi-finished and finished commodities have much greater commitments than they can handle satisfactorily.

*Foundry and Basic Iron.*—The inadequate distribution of foundry pig and the shortage of heavy cast-iron scrap is keeping the production of plants turning out castings at a lower level than is required to meet their customers' current needs. The whole of the product of the basic blast-furnaces is promptly absorbed by the requirements of makers' adjoining steelworks.

*Hematite, Low-Phosphorus and Refined Iron.*—East-Coast hematite firms continue to cover the actual needs of the regular customers, but are unable to meet the buyers' demands for extra deliveries for stocking. The distribution of low- and medium-phosphorus grades of iron is not sufficient to cover the requirements of users. There is a ready sale for the output of refined iron.

*Manufactured Iron and Steel.*—Semi-finished and finished iron firms have contracts to carry out that will ensure great activity for some time, and the demand for larger deliveries continues. There is still intense pressure for all classes of steel. Steel semies, particularly sheet bars, are needed in much larger quantities than can be provided, and the shortage necessitates a reduction in the output of black and galvanised sheet. Billets and blooms also are in greater demand than supply. Quotas of material for the production of colliery equipment, railway requirements, shipbuilding and agricultural implements are eagerly taken up.

THE INSTITUTE OF TRANSPORT.—A graduate and student society of the Institute of Transport, 15, Savoy-street, London, W.C.2, has been formed at Bolton, Lancashire.

## NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

*Iron and Steel.*—Pig-iron supplies are being heavily drawn upon and are rather short. Iron and steel scrap is also in short supply, although there are some signs of improvement. Steel and engineering works are very busily employed, the level of activity being higher than in pre-war days. Steps have been taken to conserve coal by the conversion of steel-melting furnaces to fuel oil. Sixteen open-hearth furnaces of 40 tons or more are operating on fuel oil and another will be ready in a few days. It is intended to convert a further nine furnaces, which will make it possible to save about 7,000 tons of coal a week by the end of the winter. At the works of Messrs. Steel, Peech and Tozer, 60 per cent. of their basic steel furnaces will be operating on fuel oil within the next few months. The Park Gate Iron and Steel Company have converted five furnaces and propose to equip their entire range of plant for fuel oil. A little more labour is being provided for steelworks through the system of direction, but a retarding influence is the shortage of housing accommodation. The process of re-organisation and equipment of steelworks and foundries is being hampered by delays in the delivery of machine tools.

*South Yorkshire Coal Trade.*—The longer working week at the pits is operating successfully and providing a larger output of coal which is mainly earmarked for industrial users and public-utility undertakings. Inroads upon house coal qualities are being made to provide more coal for industry and for gas, electricity and coke works. The make of coke is at as high a level as the coal supplies will permit and is fully absorbed by the iron and steel trades. A quicker turn-round of wagons has rendered the much-needed empties available at colliery screens and assisted considerably in the distribution of coal and coke.

## NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

*The Welsh Coal Trade.*—Considerable satisfaction has been felt in local coal shipping circles at the result of a meeting held last week between Lord Hyndley, chairman of the National Coal Board, and representatives of the coal exporters. The meeting discussed the future conduct of the coal export trade when shipments are resumed next year. It is understood that the coal exporters' representatives came away with the impression that the Board would not set up its own organisation to deal with shipments but would utilise the services of the exporters who handled the business before the war, established valuable contacts abroad, and have maintained them since in spite of difficulties. Another matter which the meeting discussed, and one upon which a number of prominent South Wales exporters have expressed themselves forcibly in the past, was the quality of coal to be made available for export. The opinion has been held locally that in permitting only the very poorest sorts to be sent abroad, which was the case before the fuel crisis at home brought exports to a standstill, irreparable damage was being done to the future of the trade. Trading conditions have been difficult on the Welsh steam-coal market during the past week. There has been an actively sustained home demand and although productions have been fully maintained at the recent higher levels there has been practically no free coal on offer on the market. Existing orders were sufficient to provide a ready outlet for the bulk of outputs, and the needs of inland industries and home buyers were very heavy. As a result, there was little to spare for shipment abroad and practically the only deliveries made overseas were those to special consumers in Eire and Canada. Patent fuel and cokes were in strong demand but supplies were extremely limited for several months ahead.

*Swansea Steel-Sheet Industry.*—The market report issued by the Incorporated Swansea Exchange states that, last week, the demand for tin-plates was fully maintained and that a fair volume of business was transacted with home consumers for delivery before the end of the year. In the export market slightly quieter conditions ruled and the sales were on a reduced scale. Steel sheets, and also scrap, were in great demand.

RAILWAY-TIME CENTENARY.—Greenwich time was adopted throughout the London and North Western Railway Company's system on December 1, 1847. Previously, "local" time was used at each station; Birmingham being 7 minutes behind Greenwich time, and at Liverpool and Chester, 12 minutes behind. December 1 was also the centenary of the opening, for public through-traffic, of the Trent Valley Railway between Rugby and Stafford, a distance of 49¼ miles. The new route, now forming part of the L.M.S. system, reduced the distance between London and the north-west by 8 miles, but the saving in time, compared with the previous route through Birmingham, was more than proportionate.

## NOTICES OF MEETINGS.

**It is requested that particulars for insertion in this column shall reach the Editor not later than Tuesday morning in the week preceding the date of the meeting.**

CHEMICAL SOCIETY.—Monday, December 8, 4.30 p.m., University, Edgbaston, Birmingham. "Mechanisms of Oxidation," by Dr. W. A. Waters.

INSTITUTION OF ELECTRICAL ENGINEERS.—*Western Centre:* Monday, December 8, 5 p.m., Institute of Engineers, Park-place, Cardiff. "Gas, Electricity and Coal Economy," by Mr. P. Schiller. *North-Eastern Centre:* Monday, December 8, 6.15 p.m., Neville Hall, Newcastle-upon-Tyne. "Oil Deterioration in Transformers and Switchgear," by Mr. H. Hurworth. *Radio Section:* Tuesday, December 9, 5.30 p.m., Victoria-embankment, W.C.2. "Disc Recording and Processing," by Mr. B E. G. Mittell. *Transmission Section:* Wednesday, December 10, 5.30 p.m., Victoria-embankment, W.C.2. "Oil Deterioration in Transformers and Switchgear," by Mr. H. Hurworth. "An Electrical Resistance Test for Insulating Oils," by Mr. J. S. Forrest. *Scottish Centre:* Wednesday, December 10, 6 p.m., Heriot-Watt College, Edinburgh. "The High-Pressure Mercury-Vapour Discharge," by Messrs. V. J. Francis and W. R. Stevens. *Measurements Section:* Friday, December 12, 5.30 p.m., Victoria-embankment, W.C.2. "A Combustible-Gas Detector," by Mr. R. Poole.

INSTITUTE OF TRANSPORT.—Monday, December 8, 5.30 p.m., Institution of Electrical Engineers, Victoria-embankment, W.C.2. Henry Spurrier Lecture: "Road Transport Industry and the Future," by Mr. H. T. Dutfield.

INSTITUTION OF THE RUBBER INDUSTRY.—*Midland Section:* Monday, December 8, 7.15 p.m., James Watt Institute, Birmingham. "Carbon Black," by Dr. D. Parkinson.

INSTITUTE OF BRITISH FOUNDRYMEN.—*Sheffield Branch:* Monday, December 8, 7.30 p.m., Victoria Hotel, Sheffield. "Ferrous Die Castings," by Mr. C. D. Pollard. *London Branch:* Thursday, December 11, 7 p.m., Waldorf Hotel, Aldwych, W.C.2. Meeting with INSTITUTE OF METALS. "Mechanisation of Non-Ferrous Foundries," by Mr. G. Skript.

INSTITUTION OF CIVIL ENGINEERS.—Tuesday, December 9, 5.30 p.m., Great George-street, S.W.1. "Use and Design of Mechanical Earth-Moving Plant," by Messrs. J. L. Sturrock and D. J. Simmons. *Birmingham Association:* Thursday, December 11, 6 p.m., James Watt Institute, Birmingham. "Principles and Practice of Road Location," by Mr. J. E. Cardell. *North-Western Association:* Thursday, December 11, 6.30 p.m., Engineers' Club, Manchester. "Rational Design of Settlement Tanks," by Messrs. T. K. George and K. B. Manyam.

INSTITUTE OF MARINE ENGINEERS.—Tuesday and Wednesday, December 9 and 10, 5.30 p.m., 85, Minories, E.C.3. "Burning of Boiler Fuels in Diesel Engines," by Mr. J. Lamb.

INSTITUTION OF CHEMICAL ENGINEERS.—Tuesday, December 9, 5.30 p.m., Geological Society, Burlington House, Piccadilly, W.1. "Heat Transfer in a Reaction Tank Cooled by Means of a Coll," by Mr. N. H. Pratt.

JUNIOR INSTITUTION OF ENGINEERS.—*Western Group:* Tuesday, December 9, 7.30 p.m., Grand Hotel, Bristol. Discussion Evening. *Institution:* Friday, December 12, 6.30 p.m., Royal Society of Arts, John Adam-street, W.C.2. Presidential Address: "Coronation Scot—a Railway Development," by Mr. R. A. Riddles.

NEWCOMEN SOCIETY.—Wednesday, December 10, 5.30 p.m., 4, Grosvenor-gardens, S.W.1. Annual Meeting. "La Mission de Gabriel Jars dans les Mines et les Usines Britanniques en 1764," by Mr. Jean Chevalier. "Malham Moor Mines, Yorks, 1760-1830," by Dr. A. Raistrick.

ROYAL PHOTOGRAPHIC SOCIETY.—Thursday, December 11, 7 p.m., 16, Prince's-gate, S.W.7. "Photography of Small Objects for Reproduction," by Mr. G. B. McAlpine.

INSTITUTION OF MECHANICAL ENGINEERS.—*Applied Mechanics Group:* Friday, December 12, 5.30 p.m., Storey's-gate, St. James's Park, S.W.1. "Basic Physical Properties Relied on in the Frozen Stress Technique," by Mr. W. A. P. Fisher. "Modern Applications of Photo-Elasticity," by Mr. R. B. Heywood. AUTOMOBILE DIVISION. *Coventry Centre:* Tuesday, December 9, 7 p.m., Geisha Café, Hertford-street, Coventry. "Recent Developments in Transmissions," by Professor E. M'Ewen. *London Graduates' Branch:* Wednesday, December 10, 6.30 p.m., Storey's-gate, S.W.1. "British Public Service Industry," by Mr. J. C. Gilham.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.—Friday, December 12, 6.15 p.m., Mining Institute, Newcastle-upon-Tyne. "Fire Precautions on Ships under Refit nd Repair," by Mr. E. L. Champness.

# RAILWAY BRIDGE WITH 100-FT. ALUMINIUM SPAN.

(*For Description, see Page* 529.)

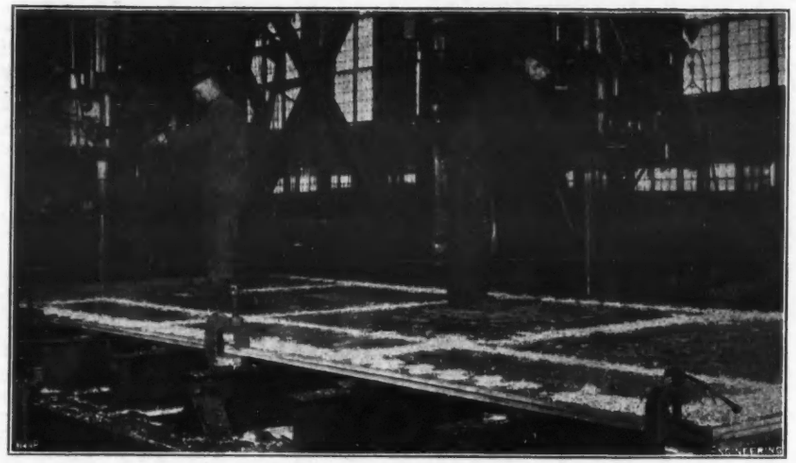

FIG. 6. DRILLING ALUMINIUM WEB PLATES.

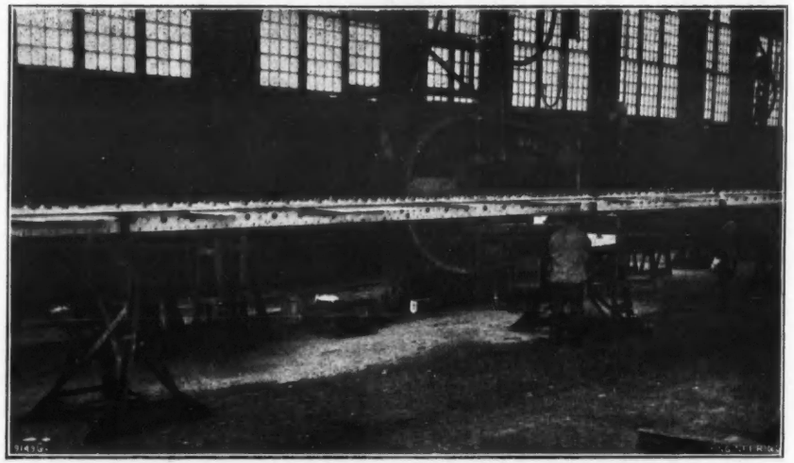

FIG. 7. CONSTRUCTION OF FLANGE ASSEMBLIES FOR WEB PLATES.

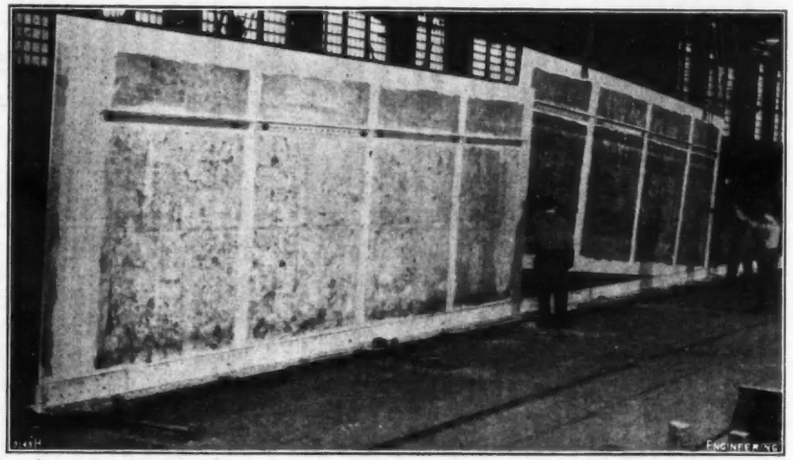

FIG. 8. INSERTING WEB PLATES IN LOWER FLANGE ASSEMBLIES.

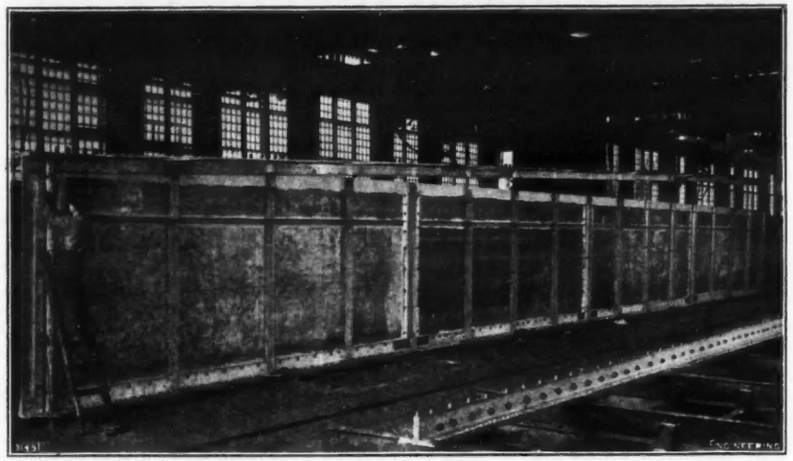

FIG. 9. ASSEMBLING TOP FLANGES ON WEB PLATES.

PUBLIC HEALTH AND MUNICIPAL ENGINEERING CONGRESS AND EXHIBITION, OLYMPIA, 1948.—Negotiations are now in progress for the amalgamation of the Public Works, Roads and Transport Congress and Exhibition, and the Public Health and Municipal Engineering Congress and Exhibition. This step would enable the promoters to organise a combined congress and exhibition to be held at Olympia, London, W.14, in November, 1950. Pending the completion of these negotiations, however, and in collaboration with the Public Works, Roads and Transport Congress Council, arrangements are being made for the programme of next year's Public Health and Municipal Engineering Congress to emphasise as much as possible the engineering aspects of the many services which are vital to the maintenance of public health. It will be appreciated, therefore, that the Public Health and Municipal Engineering Exhibition, which is to be held in conjunction with the Congress, will be on a far wider and more comprehensive basis than has been the case hitherto. As in previous years, the Exhibition arrangements are in the hands of Mr. J. Pattisson, 68, Victoria-street, London, S.W.1, and we are informed that many of the exhibitors at this year's Public Works, Roads and Transport Exhibition have applied for space for the 1948 Public Health and Municipal Engineering Exhibition, to be held at Olympia from November 15 to 20. The layout of the Exhibition is being altered to provide a gangway through the centre of the Grand Hall leading into the annexe. The central rows between the gallery columns will be reserved for exhibits lending themselves to open display.

# ENGINEERING.

35 & 36, BEDFORD STREET, STRAND, LONDON, W.C.2.

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The Proprietors will not hold themselves responsible for advertisers' blocks left in their possession for more than two years.


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# ENGINEERING

*FRIDAY, DECEMBER 5, 1947.*

VOL. 164. No. 4271.


## GERMAN WAR RESEARCH.

WITH the detachment possible towards a nation that surrendered unconditionally over two years ago, it can be admitted that German scientific achievements have been generally entitled to a good deal of respect, even from people who had most cause to fear the despicable purposes to which they were directed; and not least from the technologists of the Allied forces whose considerable task it was to master them during the war. When, therefore, German scientific establishments began to be overrun in the spring of 1945, military technicians were sent to the Continent as soon as possible to examine apparatus and equipment, and to interrogate the German scientific workers. Among the foremost of several such groups dispatched from the United States of America was Colonel Leslie E. Simon, who had been Director of the Ordnance Department's Ballistic Research Laboratory throughout the war. In many respects, his assignment was less specialised than many of those pursued in great detail later on, but for that very reason was perhaps more valuable at a date when there was information to be gained that might be of use in hastening the successful conclusion of hostilities; and more comprehensive, as embracing not only the material productions of German science, but also the organisation of German research and development for war. In addition to his official report, much of which cannot be made public for reasons of security, Colonel Simon has written a general account* of what he saw and learned in Germany which makes fascinating reading for all sorts of people concerned in all sorts of ways with scientific research.

Despite an enormous amount of destruction, partly due to Allied military action, partly to deliberate attempts by the Germans themselves to preserve secrecy, and partly, in many instances, to orgies of looting and demolition by liberated slave labour, the main features of research activity could be judged, as a rule, from the clues remaining and the interrogation of captured technicians, who were inclined rather to be proud of their work than otherwise. Actually, the destruction was much less than satisfactory from the Allied military standpoint, because the Germans had constructed many of their most secret research establishments in the form of dispersed single-storeyed buildings, deeply hidden among forests or in remote situations where they were largely immune from bombing attacks. More general information regarding the organisation of research, development and production, and the relations among the many departments and services concerned, was less directly available and proved difficult to piece together; because the individuals concerned, even of high administrative rank, had been kept in ignorance both of the major projects to which their work contributed and of the very existence of other establishments working on other aspects of the same projects. Colonel Simon's systematic investigation has probably resulted in a more comprehensive picture of German war-time research than was ever visible in Germany to more than one or two exalted figures like Göring or Speer.

Even to Colonel Simon, however, the complete picture is one of confusion, with the armed services on the one hand regarding research as the primary source of novel and powerful weapons and competing for research services, while, on the other, the research establishments were each serving several masters, the masters themselves exercising various degrees of control and jockeying for political influence, and the bodies responsible for directing research work jealous to the point of restricting the dissemination of results. The control of development work for the army was at first largely in the hands of the great armament firms, who seem to have resented interference or criticism until forced by political influence to accept reorganisation. Similarly, the German navy, while welcoming a considerable amount of disinterested research, was largely dependent on manufacturing concerns. The *Luftwaffe* alone had an effective and competent research organisation, unhampered by tradition and undeterred by complexes from exploiting academic and industrial resources, as well as utilising to the full an array of modern research establishments which Colonel Simon describes as the most magnificent, carefully planned and fully equipped that the world has ever seen. What was widely known outside Germany before the war, from official reports, goes to confirm Colonel Simon's impression of German aviation research during the early part of the war. To pre-war knowledge, however, he adds an acute analysis of the reasons why so vast a body of potential scientific achievement failed to anticipate long-term requirements and to provide for an adequate sequence, through technology and development, to production. Of special interest is his view that Speer had a contempt for science as it was being applied in Germany during the war, and was so engrossed in plans for production that, when scientific help was eventually and reluctantly accepted, it came too late to be effective. In addition to this, Colonel Simon considers that German scientific competence has been greatly overvalued.

One result of the relative superiority of research on behalf of the Air Force is that many of the outstanding scientific developments used by the Army and the Navy were in the domain of fluid mechanics. Aerodynamic equipment ranged from the 8-m. subsonic wind tunnel, at the Luftfahrtforschungsanstalt Hermann Göring, near Brunswick, to the 4·4-Mach number supersonic tunnel at Kochel, near Munich. At the end of the war, an 8-m. sonic-velocity tunnel was under construction at Otztal, in the Bavarian Alps, while plans were well advanced for a supersonic tunnel designed for continuous pressure operation up to a Mach number of 10. Calibration of the completed tunnels was facilitated by means of various families of standard model forms, approximating in shape to projectiles, which were used along with Pitot-tube pressure-plotting techniques for developing artillery shells, arrow-projectiles and a long series of rockets of the V-2 type. Perhaps the most interesting supersonic tunnel accessory was an optical interferometer, by means of which contours of equal air density could be observed and photographed as an aid to exploring the pressure distribution round solid boundaries immersed in the airflow.

* *German Research in World War II.* By Leslie E. Simon. John Wiley and Sons, Inc., 440, Fourth-avenue, New York 16, U.S.A. [Price 4 dols.]; and Chapman and Hall, Limited, 37, Essex-street, London, W.C.2. [Price 24*s.* net.]

Despite the predominance, in the later years of the war, of missiles that were primarily aerodynamic in character, the best of which incorporated the sharply swept-back wing which was perhaps the most outstanding German contribution to supersonic flight, a good deal of interesting research was carried out on more ordinary problems of interior and terminal ballistics. High-pressure phenomena and time-temperature relations were studied for several types of guns. Associated with such work were novel thermocouples and devices for high-speed photography. Noteworthy among the latter were the Cranz-Schardin camera, which took 24 exposures at the rate of five million per second; and the Kerr-cell camera, which took four pictures at a rate of eight million per second by means of polarised light. Flash photography, by the brief discharge of a powerful X-ray tube, was also used for ballistic work on lines parallel to those developed in England and America. Terminal ballistics research was directed to the effects of the shape of armour and projectile on penetration, while spaced armour for resisting armour-piercing bombs, and safety glass intended to withstand steel-cored bullets, were studied experimentally as well as theoretically. The directional effects of shaped explosive charges were known and applied throughout the war, but the German work seems to have been less original and less advanced than that of the Allies in this subject. They paid a great deal of attention, however, to the characteristics of explosive shock-waves, and an imposing establishment, built on the very summit of the Zugspitz—the highest mountain in Germany—was the site of experiments to determine the effect of altitude on blast, as well as of radar research.

British readers, other than specialists in armaments or aerodynamics, will be particularly interested in those examples of German invention which immediately affected this country and its fighting men abroad, or would have done so eventually had the war not ended when and how it did. Among scientific instruments, a cathode-ray oscillograph having a writing speed one-third that of light is, perhaps, outside that category, but within it are the photo-theodolites which took such clear pictures of Dover, 25 km. away, that the guy wires on the radio masts could be distinguished. For detecting infra-red radiation, a small viewer containing phosphorescent chemicals was apparently very successful; so also were some of the fin-stabilised projectiles fired from a rifled gun, and many of the rockets developed for air combat, raiding and anti-aircraft purposes. After the potentialities of the V-2 rocket were demonstrated in 1943, Hitler became highly enthusiastic about rockets of all sorts, as well as jet-propelled projectiles and aircraft, and was instrumental in encouraging the design of first-rate fighters such as the turbo-jet Messerschmitt 262, which was intended to have rocket armament and would have proved a serious threat to Allied air superiority but for the crippling shortage of petroleum.

There were also a number of freakish proposals, some of which never appeared in combat. A firm in Stuttgart designed an anti-aircraft gun to shoot a plug of compressed air which broke 1-in. boards at 200 m., but was ineffective against aeroplanes at normal ranges. A Dr. Wallauscheck produced a parabolic reflector fitted with a chamber behind the vertex, in which sound was generated by the rapidly repeated explosion of a methane-oxygen mixture. The intense noise was intended to disable troops against whom it was directed. Still more menacing was the super-gun with a range of 80 miles, designed to fire arrow projectiles at London. It had 28 powder chambers spaced along the bore, in which successive explosions boosted the 150-lb. projectile up to a muzzle velocity of 4,500 ft. per second.

Engineers, mindful of the ranks of Tuscany, will hardly withhold a purely technical approbation from German war research, some of which has undoubtedly advanced the frontiers of science. The very fact, therefore, that so much misapplied ingenuity may eventually produce good results, despite its deplorable origin, is a powerful inducement to use Colonel Simon's book as a guide to the solution of problems arising in the organisation of scientific research for peace.

## THE RETRENCHMENT PROGRAMME.

THE White Paper [Cmd. 7268] on *Capital Investment in* 1948, which was issued on Monday, December 1, sets out the Government's plans for "bringing the volume of new investment undertaken into proper relation with the reduced supplies of materials, industrial capacity and man-power that we can afford to make available for this purpose." In other words, an attempt is to be made at last to adopt the wise policy of cutting the national coat according to the available cloth. In an endeavour to perform this difficult task of retrenchment, the main resources are to be concentrated "on those types of investment which will most quickly strengthen our capacity to export and will buttress such services as coal, electricity, steel and transport, which are basic to our whole industrial strength." In addition, "the number of new projects proceeded with must be limited, so that the more important schemes may be completed as rapidly as possible." In this way it is hoped that the rate of total gross investment, including repairs and maintenance, will be reduced during 1948 to 130,000,000*l.* per annum below the recent annual rate, and that by the end of that year the rate of expenditure will be 230,000,000*l.* less than at the present time.

Naturally, all branches of engineering will be affected by this plan. It will be of interest, therefore, to make some examination of its details. In the first place, it may be noted that the axe will fall on programmes rather than on work which is already in progress. For instance, under the heading of transport, the schemes upon which work will continue include the Deptford Creek bridge, the diversion of roads at the Imperial Chemical Works on Tees-side, and the electrification of the Manchester-Sheffield and the London-Shenfield lines of the London and North Eastern Railway. The full railway programme of nearly 600 new locomotives and 48,000 new wagons will also go forward. The labour engaged on the modernisation of the coal mines, on the development of electricity supplies, the rehabilitation of gas-making plant and on the provision of facilities for the coal-oil conversion programme, will even be increased from 20,487 in June, 1947, to 27,000 in June, 1948. The annual capacity of plant installed in electric generating stations will rise from 1,150 MW in 1948 to 1,600 MW in 1949. Thereafter, however, it will be limited to 1,500 MW per annum. The North of Scotland water power projects will proceed, subject to review. The value of the agricultural machinery manufactured for the home market will be increased from 30,000,000*l.* in 1947 to nearly 40,000,000*l.* in 1948 and the following years, half of which will be for tractors and the remainder for other plant. In this connection, it may be recalled that the allocation of steel to this branch of the engineering industry has been doubled recently, to meet the demand for increased production for home and export.

As regards other plant and machinery, the total production will be increased from an annual rate of 110,000,000*l.* to 121,000,000*l.* by the end of 1948, although a greater proportion of the total output than at present will be allocated to export. The value of the shipping delivered to British owners in 1947 will be 48,000,000*l.*, while that of the exports will be 15,000,000*l.* During 1948, the corresponding figures will be 50,000,000*l.* and 25,000,000*l.*, it being considered that it is as advantageous to build ships for British owners as for export, even to hard-currency countries. The development of new towns designed to serve immediate industrial needs or mining areas, such as Aycliffe, Easington and East Kilbride, is to be continued, as are the Whitehall building scheme and the reconstruction of the House of Commons.

On the other hand, constructional work on the Severn bridge, the Dartford tunnel, the Great West-road and Cromwell-road extensions, the Widnes-Runcorn bridge and the main Jarrow tunnel is to be postponed. Road maintenance also will be reduced to an extent which will release 20,000 men for other work. The Notting Hill Gate station reconstruction and the rebuilding of Euston station will be deferred; and the output of new railway coaches also will be limited to the present figure of 1,000 a year. Owing to the steel shortage, materials for permanent way will be reduced to current needs without overtaking arrears, so that the imposition of speed restrictions will have to be continued. A much larger proportion of road-vehicle production will be diverted to export, and the supply for the home market will be halved. The results of the restrictions on the supply of electric-generating plant to the home market will mean a deficit of 824 MW as late as the winter of 1951-52, the practical consequence being that load shedding will be necessary at intervals at least until that date. The labour engaged on the provision of facilities for civil aviation will be reduced to 1,700 during 1948, though it is anticipated that this will enable works essential to safety, some new works on a reduced scale, and the necessary maintenance to proceed.

The labour force engaged on the telephone system will also be cut down by 1,000, the principal result being that a great deal of cable laying will have to be postponed. This will materially restrict the possibility of connecting up new subscribers and the waiting list will steadily grow from its present figure of nearly half a million. Work on new towns, such as Stevenage, Crawley and Hemel Hempstead, will be limited during 1948 to the provision of water, sewerage and roads; and for at least six months no new industrial buildings or extensions will be started, other than those of importance to exports or in saving imports. All factory building including extensions, now in progress, which has not reached the steel-erection stage, will be reviewed with the object of postponing at least half of them. There will naturally be a corresponding decrease in the amount of labour engaged on this class of work. The building of employment exchanges will cease and the new accommodation proposed for the Foreign Office, the Colonial Office and on the south bank of the Thames will not be included in the 1948 programme.

The principal criticism that may be made on these proposals is that they are too little, and that they may be too late; for while it is true that the existing gross estimate of expenditure of 1,600,000,000*l.*, as a result of them, will be cut by 180,000,000*l.*, it may well be argued that even this is not large enough, unless it is followed, as the *Manchester Guardian* has pointed out, by a very heavy cut in current incomes. It seems clear, therefore, that even more strenuous efforts will have to be made to increase export trade; and it is difficult to see how this can be done unless more labour and more factory equipment are made available. Although no estimates are given on this important subject in the White Paper, even a superficial calculation shows that the amount of labour that will be set free by the economies that are suggested will be comparatively small. As a result, therefore, the undermanned industries can be expected to obtain but few recruits. It is further obvious that any increase in output will have to be obtained mainly with existing plant, and that to maintain this in a condition suitable for the purpose more repairs are likely to be required. The slowing down of the rehabilitation of the railways, moreover, cannot fail to have a harmful effect on trade generally. Finally, the home demand and the necessity for higher exports will continue to work in opposition, so that the requirements of one or the other will have to suffer further reduction if the position is to be improved. Unfortunately the decision as to which of these alternatives should be selected may not be entirely free, since there is no guarantee that it will be possible to maintain the present volume of export trade, still less to increase it.

Nevertheless, it is undoubtedly the duty of those engaged in the engineering industry to exert all their energies to make the plan work. In doing so, it may be necessary to exercise some self-denial in criticising points of detail in the scheme; and even to resist the temptation to point out that if the situation had been handled more realistically earlier the present crisis need not have arisen. The stubborn fact is that the country is in a parlous condition, and desperate remedies must be applied to save her. It may even be argued that the economies now proposed are not sufficiently drastic to effect this object.

# NOTES.

### THE ROYAL SOCIETY.

PROPOSALS for the organisation of an Isaac Newton Observatory at Hurstmonceux were communicated to the Royal Society, by the First Lord of the Admiralty, in November, 1946, and in accepting the proposals, the Council of the Society nominated Dr. C. R. Burch, Lord Cherwell, Sir Thomas Merton and Sir Geoffrey Taylor to be their representatives on the Board of Management. Particulars of the proposed Isaac Newton Observatory are given in the report of Council of the Royal Society, presented at the 285th anniversary meeting of the Society, held in London on December 1. This states that the Observatory will be situated in the grounds of Hurstmonceux Castle and that it will house a 100-in. telescope. The scientific work will be under the direction of a special Board of Management, with the Astronomer Royal as chairman and the directors of the Royal Observatory, Edinburgh, the Cambridge Observatory, and the Oxford University Observatory as *ex officio* members. In addition to the four nominees of the Royal Society, whose names are given above, there will be four nominees of the Royal Astronomical Society, each nominee serving on the Board of Management for four years, and one nominee of each society retiring annually. The secretary of the Board of Management is to be the secretary of the Greenwich Observatory. The capital costs of the new observatory, which are stated to be in the region of 250,000*l*., are to be defrayed by the Government, while the maintenance costs, which are estimated at about 4,000*l*. per annum, are to be met from Navy Votes. The administration of the Observatory will be vested in the Astronomer Royal, who will submit an annual report for the consideration of the Visitors to the Royal Observatory. In his anniversary address, also delivered at the meeting on December 1, the President of the Royal Society, Sir Robert Robinson, gave some particulars of the recipients of medals awarded during 1947. Thus, the Copley Medal, he said, had been awarded to Professor G. H. Hardy, F.R.S., for his outstanding part in the development of mathematical analysis. Two Royal Medals had been awarded for 1947, the first to Professor C. N. Hinshelwood, F.R.S., for his work in chemical kinetics, and the second to Dr. F. M. Burnet, F.R.S., for his researches on viruses. The Davy Medal had been awarded to Professor Linus Pauling, for his researches on molecular structure; the Buchanan Medal to Sir Edward Mellanby, K.C.B., F.R.S., for his work on the physiology of nutrition; and the Hughes Medal to Professor J. F. Joliot, For. Mem. R.S., for his researches in nuclear chemistry and physics.

### WORK OF THE GAS RESEARCH BOARD.

The first day of the 13th Autumn Research Meeting of the Institution of Gas Engineers, held in London on November 25 and 26, was concerned with the discussion of reports of the Technical and Education Committees of the Institution and with the presentation and discussion of papers dealing with gas burners. The second day of the meeting was devoted to the discussion of the work of the Gas Research Board, and, in the course of an introductory address, Dr. H. Hollings, chairman of the Council of the Board, said that the investigation on the gasification of coal under pressure was proceeding at Bournemouth in a vessel originally designed for the study of the hydrogenation of coal. On the advice of the panel which had this work under review, the Council was now considering the practicability of obtaining a new pressure vessel designed primarily for the study of the behaviour of various bituminous coals when gasified under different pressures of steam and air. The new programme concerned with the removal of hydrogen sulphide from gas had made a very promising start and work on this was being extended at Bournemouth. The Council had decided that the questions relating to wind stresses in spirally-guided gasholders should be explored further, and, with the assistance of the panel in charge of such work, it was hoped to plan a series of observations on a full-size holder, which should assist designers. Work on the synthesis of methane was well advanced and a final report would be presented in a few months. On the other hand, the investigation on the size distribution of coke, with particular reference to the study of works screening and cutting processes, was proceeding more slowly than was thought desirable, on account of delays in securing the necessary apparatus and for other reasons. In conclusion, Dr. Hollings explained the position regarding the headquarters of the Board. He said that the purchase of a site at Beckenham had been completed and it now appeared that, before the next meeting, the Board might have vacant possession of an existing building. After essential repairs, this would house the director and a part of the research staff, together with the intelligence and clerical staffs. Altogether, the moves now within sight would result in a better co-ordination of the Board's present activities.

### THE CORNISH ENGINES PRESERVATION SOCIETY.

An interesting ceremony marked the general meeting of the Cornish Engines Preservation Society, which was held on Saturday last, November 29, in the engine house of what is known as "Taylor's Shaft" at the East Pool and Wheal Agar mine, near Redruth, Cornwall. The Society, though still small in numbers, has been successful in preserving from demolition some typical specimens of the smaller types of Cornish mining engines, but had been much concerned lest the larger types of Cornish engine, already reduced to very few, should disappear altogether from the county which gave them their name, before funds could be raised to purchase one or more of them. The 90-in. engine at Taylor's Shaft, which is still at work, recently came into the market and, by the generosity of Mr. Greville Bathe, a member now resident in Philadelphia, who contributed the whole of 250*l*. needed, the Society was enabled to buy it, with the engine house. At the meeting on Saturday, Lord Falmouth, as President of the Society, accepted from Mr. W. Tregoning Hooper, who is one of the two honorary secretaries, the title deeds of the engine and house. How long the engine will continue to work is uncertain at present, but eventually, when it is no longer required for pumping, the intention is to use the engine house as a museum in which to display some of the drawings, photographs, etc., of Cornish engines, now in the Society's possession, as has been done in the case of the Cruquius engine at Haarlem, in Holland. For this purpose, additional funds are required to provide an endowment to cover maintenance charges, and an appeal has been made already for this purpose, which Mr. F. J. Pascoe, chairman of Messrs. British Timken, Limited, has launched with a donation of 25*l*. It is understood that American mining engineers also are interesting themselves in the project. The Taylor engine was constructed in 1892 by Messrs. Harvey and Company, of Hayle, to the designs of the late Mr. Nicholas Trestrail, A.M.I.C.E., and was erected initially at the Carn Brea mine, being removed to its present position in 1924. The cylinder is 90 in. in diameter, and the stroke is 10 ft.; the maximum indicated horse-power is about 425. When first erected, the engine gave a duty of 56,500,000 ft.-lb. per hundredweight of coal, corresponding to a consumption of 3·9 lb. of coal per horse-power-hour. The beam is of cast iron and weighs 52 tons. A balance bob is fitted at the surface, and this, it is expected, will enable the engine to be moved occasionally, for demonstration purposes, even after the pitwork has been dismantled or has become unserviceable.

### CONSTRUCTION OF MEAFORD POWER STATION.

The constructional features of Meaford power station, of the North West Midland Joint Electricity Authority, were described in a paper read before the Institution of Structural Engineers, at 11, Upper Belgrave-street, London, S.W.1, on November 27, by Mr. F. T. Bunclark, B.Sc., M.I.C.E., M.I.Struct.E. The capacity of the station is 120 MW, and the official opening in October was briefly recorded on page 399, *ante*. Mr. Bunclark gave a general description of the station, but he dealt principally with the practical work of construction. The site is near Stoke-on-Trent, adjacent to the London Midland and Scottish Railway main line, and the Trent and Mersey Canal; and the station has been designed to meet the increasing domestic and industrial demands of the Potteries. Coal consumption is estimated at 5,750 tons per week; sidings are provided for 250 20-ton wagons; and 60,000 tons of coal can be stored at the station. The effluent from the near-by Strongford sewage works is used for cooling water, and is circulated through two hyperbolic cooling towers. Feed water gravitates from a reinforced-concrete reservoir of 250,000 gallons capacity, about one mile from the station. The load on the ground from the boiler-house stanchions is 4 tons per square foot; each of the two chimneys weighs 5,400 tons and imparts a load of 3¼ tons per square foot; and the turbo-alternators impose an average load of 1·2 tons per square foot. Owing to the varying nature of the ground, *in-situ* bearing piles have been provided throughout the site. A concrete-mixing station was established, and the concrete pumped through a 6-in. steel pipe, to a maximum distance of 987 ft. The foundation for each turbo-alternator contains 110 cubic yards of concrete at the steam end, and 214 cubic yards at the generator end. Shuttering was built of steel frames with plywood facing, and the concrete was poured at an average rate of 13¾ cubic yards an hour. The cooling-water culverts were built of reinforced concrete, using travelling forms; the cross-section of the culverts is square with the corners "bevelled." Ash and dust will be pumped as slurry to two ash ponds with a capacity of 550,000 cubic yards—sufficient for seven years. Four other ponds will probably be provided under a future contract, and land is available for further extensions. Excavation for the foundations was commenced in February, 1945, and although it was hoped to have opened the station in June, 1947, the opening was delayed until October by the severe weather early in the year. A power station of equal or greater capacity will be built on an adjacent site at a later date, and the coal-storage area and sidings will then serve both stations.

### NATIONAL FOUNDRY COLLEGE.

Formed in direct succession to the British Foundry School, which was inaugurated in Birmingham in 1935 and closed on the outbreak of war in 1939, the National Foundry College has now been established. The Board of Governors of the College has been nominated by the Minister of Education and represents trade associations, technical institutions and research associations connected with the foundry industry; the chairman is Mr. Randall G. Hosking. The College will be housed in, and will work in close collaboration with, the Wolverhampton and Staffordshire Technical College. The Governors are charged with the responsibility for providing national facilities for foundry education and research in all branches of ferrous and non-ferrous metal founding, in the form of full-time courses, and vacation, refresher and other courses, and also for providing regional and local facilities for full-time and part-time day and evening courses, thereby covering the whole range of foundry education. The Governors' first task will be the re-establishment of the full-time diploma course which was the main feature of the British Foundry School during the period 1935-1939. This course will normally run for an academic year of 40 weeks, from September to July. It is hoped, however, to open the College on January 5, 1948, and to hold a somewhat abbreviated first course ending in August, 1948. There is no upper age limit for admission, but the standard of practical experience and technical knowledge of candidates must satisfy the Governors that they are in a position to profit from the instruction. The fee for the course is 60*l*., but, at the discretion of the Governors this fee may be remitted, wholly or in part, for students nominated by firms belonging to trade associations or bodies contributing financially to the College. It is hoped to provide hostel accommodation for students in due course, but this is unlikely to be ready before the first session is completed. The new Head of the College is Mr. James Bamford, B.Sc., who was in charge of the British Foundry School from 1935 to 1939, and applications for prospectuses and forms of admission should be made to him at the National Foundry College, The Technical College, Wulfruna-street, Wolverhampton.

THE SOUTHWICK "B" GENERATING STATION OF THE BRIGHTON CORPORATION.

The first pile of the Southwick "B" generating station of the Brighton Corporation was driven on Tuesday, November 25, by the Mayor (Councillor P. F. Friend James, O.B.E.), assisted by the employee with the longest service in the department (Mr. B. Jeal). The station, which lies adjacent to the existing plant, is designed for an ultimate capacity of 315 MW, which will be made up of six 52·5-MW sets. Only the first half of the station will be constructed to begin with and this should be completed by 1950. The buildings, which will be about 900 ft. long and 350 ft. wide, with a 350-ft. chimney at each end, will be constructed on a raft consisting of 4,500 55-ft. reinforced concrete piles, which are being driven by Messrs. Holloway Brothers (London), Limited. The turbine house will be a reinforced-concrete structure with brick-filling, while the boiler house will consist of a steel frame, which will also be filled in with brick-work. The steam-raising plant will consist of six boilers, each of which will supply 320,000 lb. of steam per hour at a pressure of 900 lb. per square inch and a temperature of 900 deg. F. These boilers, which will be constructed by Messrs. Babcock and Wilcox, Limited, Farringdon-street, London, E.C.4, will be fired with pulverised fuel and will be equipped with dust-extraction plant incorporating both mechanical collectors and electrostatic precipitators. The turbo-alternators are being supplied by Messrs. Richardsons, Westgarth and Company, Limited, Hartlepool. The station has been designed by Mr. H. Pryce-Jones, engineer and manager of the Corporation Electricity Department, while Messrs. L. G. Mouchel and Partners, 38, Victoria-street, London, S.W.1, and Sir William Halcrow and Partners, 65, Westminster-gardens, London, S.W.1, are acting as consultants for the foundations and buildings; and the circulating-water system, harbour works, and roads, respectively. The consulting architect is Mr. J. H. Somerset.

# LETTERS TO THE EDITOR.

## CREEP AND SHRINKAGE IN REINFORCED CONCRETE.

TO THE EDITOR OF ENGINEERING.

SIR,—May I ask you again for the hospitality of your columns?

Mr. Seed says in the second paragraph of his letter, on page 496, *ante*, that two columns with 2 per cent. of reinforcement, the one designed with $m = 15$ and a maximum working stress of 1,140 lb. per square inch on the concrete, the other with $m = 27$ and a maximum working stress of 26,000 lb. per square inch on the steel, "will be identical and the stresses developed will be the same at all times." If this is so, what is the point in changing the modular ratio? In the third paragraph, he assumes a concrete of poorer quality with $m = 15$ and a maximum working stress on the concrete of 750 lb. per square inch and tries to show that, in this case, the use of $m = 27$ would lead "to a greater economy."

The whole argument overlooks the fact that so-called "permissible" or "working" stresses are only a means of assessing the load-bearing capacity of a reinforced-concrete member. It would be more appropriate to call them "design" stresses. They are based on arbitrary assumptions, applicable to one particular loading condition only, and bear no relation whatever to the stresses actually occurring under working loads. As I pointed out in my previous letter, in certain cases, even the yield point of mild steel may be reached in columns designed in accordance with present by-laws. At the same time, the concrete stress may be reduced to approximately zero. Such a stress distribution is equivalent to $m$ approaching 88, which reduces the whole conception of the modular ratio to absurdity. A maximum working stress of 26,000 lb. per square inch would be as arbitrary as any other constant working stress if it is supposed to represent actual stresses. On the other hand, used indiscriminately as "design" stress, it may result in an inadequate factor of safety.

Although we cannot prevent stresses of the order of 26,000 lb. per square inch, and even substantially more, actually occurring in reinforced-concrete columns under working loads because of the redistribution of stresses between steel and concrete, such stresses are not "allowed" in the design. They are "illegal," since the composite material "reinforced-concrete" does not obey the laws specified by the standard method of design. A change of $m$ from 15 to 27 with "design" stresses of the order of 26,000 lb. per square inch would limit the concrete stress to 963 lb. per square inch and would upset completely the fictitious basis of the standard method; that is, the assumption that the factor of safety is the ratio $\frac{\text{yield stress}}{\text{working stress}}$. The variation of the real factor of safety, that is, of the ratio $\frac{\text{ultimate load}}{\text{permissible load}}$, would remain as great as before, or become even worse.

Any attempt to the effect that "the stresses developed in a concrete structure throughout the greater part of its life should be equal to those envisaged in the original design" is doomed to failure as long as we adhere to the idea of permissible stresses, unless we go with the permissible stress as high as the yield point of mild steel. Such high stresses could never be admitted in Codes. It is futile to try to "improve" a method based on wrong principles.

The application of a formula already incorporated in an official document in 1934 would not constitute a "sudden change of design method." The only obstacle is the reluctance of engineers to part with formulæ sanctioned by a tradition of 50 years or so. The best method to improve the present situation is to teach the younger generation of engineers the results of recent research and to enable them to apply these results in practice.

Yours faithfully,
K. HAJNAL-KÓNYI.

7, The Park,
Golders Hill,
London, N.W.11.
November 29, 1947.

## THE ENGINEERS' GERMAN CIRCLE.

TO THE EDITOR OF ENGINEERING.

SIR,—Many members of the professional engineering institutions will recall the activities of the Engineers' German Circle during the years preceding the war. It has been decided that there is little prospect of reviving the activities of the Circle and the question has arisen of the disposal of the small surplus, just over 100*l*., standing in the name of the Circle. The committee have agreed that, in view of the considerable support given to the Circle by the Institution of Mechanical Engineers, this money would most appropriately be handed over to the Benevolent Fund of the Institution.

With the lapse of time the membership has largely dispersed, and we should be grateful if you would allow us to inform the former members of this decision through the columns of your journal.

Yours faithfully,
S. J. DAVIES, President.
E. L. DIAMOND, Hon. Sec.

University of London, King's College,
Faculty of Engineering,
Strand, London, W.C.2.
November 26, 1947.

REGIONAL GROUPING OF ELECTRICITY SUPPLY UNDERTAKINGS.—The territories of the Area Boards, which have been formed under the Electricity Act, 1947, have now been delineated, and lists of the existing undertakings which are to be absorbed by these bodies are given in Statutory Rule and Order 2465 of 1947. Sixteen of the undertakings give supplies in territories which fall into the areas of more than one Board. For the time being, these are allocated to one area, owing to the working of the Act, but the necessary transfers will be made after the vesting date. Maps showing the areas covered by the various Boards are being displayed in Room 162, Ministry of Fuel and Power, 7, Millbank, London, S.W.1, between 10 a.m. and noon and 2 p.m. and 4 p.m.

# THE IRON AND STEEL INSTITUTE.

(*Concluded from page* 521.)

WHEN the members reassembled on the morning of Thursday, November 13, at the offices of the Iron and Steel Institute in London, for the last session of the Institute's annual autumn meeting, the President, Dr. C. H. Desch, F.R.S., again occupied the chair.

FLUIDITY OF STEEL.

The first contribution considered dealt with "The Fluidity of Steel" and contained a description of experiments conducted at Messrs. Hadfields Limited, Sheffield, by Dr. R. Jackson, Messrs. D. Knowles and T. H. Middleham and Professor R. J. Sarjant. The paper was presented by Mr. Middleham. The authors stated that they had investigated the fluidity-temperature relationships, as indicated by Ruff and spiral mould tests, of four steels, namely, a 2 per cent. copper steel, a silicon-nickel steel, a low-carbon steel, and a 13 per cent. manganese steel, melted in high-frequency furnaces with acid and basic linings. The essential feature of the mould in the Ruff test was the provision of a horizontal flow channel $\frac{1}{8}$ in. in diameter and $21\frac{1}{2}$ in. long. This was fed from a conical head, through a gate of standard design and dimensions. The spiral test, in which the molten steel was poured into a flow channel, spiral in form, was similar to that used by the American investigators, H. F. Taylor, E. A. Rominski and C. W. Briggs. Temperature measurements were made by optical and quick-immersion couple methods, and curves were obtained by plotting the length, in inches, of the fluidity test-piece, against the temperature of the molten steel. The spiral mould was found to give more consistent results than the Ruff mould. There was a wide discrepancy between the results for fluidity given in the present paper and those obtained by Taylor and his colleagues. The discrepancy seemed too large to be due to a real difference in the nature of essentially the same steels, or even to the sum of small experimental or equipment errors. A possible explanation was the difference in the methods of measuring temperature, errors of at least 25 deg. C. being conceivable using the methods of Taylor and his co-workers.

Dr. W. C. Newell, who opened the discussion, stated that the investigation under consideration was one of the first to take advantage of the new quick-immersion pyrometer method available for the reliable measurement of temperature. One of the outstanding conclusions, which would be of great help in future work on fluidity, was the authors' clear recommendation of the Taylor, Rominski and Briggs spiral fluidity test, and this in spite of the fact that they had started their investigation under the impression that the simpler Ruff test would suit their needs. A second point was the valuable information given on the correlation of the optical pyrometer readings with those obtained by the quick-immersion pyrometer. There was much valuable information in the early part of the paper on the relative readings for different types of steel, acid and basic, and, in particular, the discrepancies shown between the acid and basic steels were most useful, apart from any fluidity questions which might arise. A third point was the close correlation between the fluidity and the optical pyrometer reading as compared with the correlation between the fluidity and the quick-immersion temperature reading. Metallurgists usually thought that acid steel was more fluid than basic and by the optical pyrometer this appeared to be confirmed. By comparison of the immersion readings against fluidity, however, it was seen that there was scarcely any difference; if anything, the bias was the other way. Plotting true temperature against fluidity, the correlation of the two was very close, independently of whether the material was acid or basic steel. With regard to the mechanism of fluidity, the authors had suggested that surface films played a part. He personally felt convinced that the surface film was the determining factor in so far as fluidity was concerned. Evidence pointed to the fact that the internal viscosity of steel was very low, and it

seemed that the factor which determined fluidity was the surface effect, or more probably the surface tension of any oxide or slag film formed on the steel. The present work had demonstrated once again that the term "fluidity" was a misnomer, and that some better name should be coined. The only one he could think of, which fitted, was "foundability."

On this question, the President stated that "castability" seemed to be the term in general use among foundrymen. There was an objection to the word "fluidity" because it had a definite physical meaning, namely, as the reciprocal of the viscosity, whereas what was being discussed under the name of "fluidity" was actually a combination of properties. Mr. N. H. Bacon, who closed the discussion, said that the fact, which had been established, that at the true temperatures, acid and basic steels were of equal fluidity, was of particular value. This came as a great surprise to those connected with melting shops, who always thought that acid steel was more fluid than basic. Apparently the present investigators had given the correct explanation; the two steels appeared to be at the same temperature when actually there was a marked difference. The authors, on being called upon to reply to the discussion, intimated that they would do so in writing.

### Carbon Removal in Open-Hearth Furnaces.

The second paper considered was entitled "The Mechanism of Carbon Removal in the Open-Hearth Furnace," and was by the late Dr. A. H. Jay. Mr. G. E. Speight, who presented the paper, stated that it gave an account of the development of a suggested mechanism for the carbon-removal action from liquid steel in open-hearth furnaces. A new approach had been made to the mechanism of the process. It was considered that the reactions took place within a gas phase in the molten-steel bath. The reactions were considered to be as follows: (1) C (soluble) + O (soluble) → CO (insoluble molecular gas bubble); (2) CO + O → $CO_2$; (3) $CO_2$ + C → 2CO. A two-stage reaction (equations (2) and (3)) thus proceeded with subsequent growth of the bubble. In view of the very low ratio of oxygen to carbon in the medium-high carbon ranges, it was considered that reaction (2) was the governing factor in determining the ultimate speed of carbon removal. Experimentally, it had been observed that a bath of liquid steel could hold many times the equilibrium amount of oxygen until the steel was disturbed, after which rapid reaction followed.

Dr. J. H. Whiteley, who opened the discussion, stated that there were several possibilities which Dr. Jay had not taken sufficiently into account, even if he had thought of them. The first was the likelihood of the reaction:—

$$SiO_2 + 2Fe \rightarrow 2FeO + Si$$

taking place, the iron oxide passing into the slag and the silicon into the metal. If it did take place, the reaction was most likely to occur towards the finishing period of the boil, when the temperature was high and the iron oxide in the slag was low. The result would be that the silicon content would rise in the bath. Dr. Jay's figures had shown that such was indeed the case, and this was, therefore, an argument in his favour. Unfortunately, however, it was the only argument which supported Dr. Jay's theory. A consideration of the slag-metal and other reactions made him dubious concerning the theory. A subsequent speaker, Mr. H. O. Howson, said that after reviewing the reactions, the conclusion was arrived at that, in the acid open-hearth process, the removal of the carbon occurred to a very large extent as a result of actual oxidation by the furnace atmosphere. He regretted that no mention of temperature had been made in the paper. In all furnace reactions, the basic included, temperature played a very important part and, more particularly perhaps in the acid open-hearth process, temperature was the determining factor. The next speaker, Dr. C. Sykes, F.R.S., said that most of those who had taken part in the discussion had been concerned with what happened after the boil had started. He believed that, at all events as far as the oxygen limit was concerned, the author had dealt with the conditions necessary to start the boil. In a brief reply, Mr. Speight said that he felt sure that Dr. Jay's purpose had been amply fulfilled, because his paper had stimulated thought on the subject. The main object of the paper had been to show that the rate of carbon removal was proportional to a greater extent to the oxygen content than to the product of the oxygen and carbon contents. Using the one example quoted in his paper, Dr. Jay had shown that the rate of carbon removal in the early stages was about 2½ times the rate at the later stages, and from that he had argued that the states of oxidation in the first part, and at the later stage, were more or less in the ratio of 2½ : 1. Most of the published data on the oxygen content of steel seemed to indicate that this increased as the carbon content decreased. Looking back through their records he had found work done three years previously in which an acid cast had been investigated, and it had been found by actual determination that the oxygen content decreased in the same way as the carbon decreased.

### Refining of High-Phosphorus Iron.

The last paper considered by the meeting bore the title "Some Aspects of the Refining of High-Phosphorus Iron" and was by Mr. W. L. Kerlie, of Messrs. Stewarts and Lloyds, Limited, Corby. He stated that the rising costs of fuel and hematite iron, and the economic advantages attending the use of greater quantities of home ore, were leading to a demand for a process of refining high-phosphorus iron whereby a metal suitable for subsequent use in the open-hearth furnace was prepared. It was assumed that a 150-ton furnace was available. The economics of such a process would be adversely affected if the slag produced had a low $P_2O_5$ content or was otherwise unsuitable as a fertiliser. The idea of refining high-phosphorus iron to a composition suitable for fixed furnaces was particularly attractive and, throughout the paper, this idea had been borne in mind. It would appear to be technically possible to refine high-phosphorus iron with little loss of carbon, providing close control of temperature and slag composition were maintained. The smaller the amount of phosphorus to be removed, and the greater the permissible carbon drop, the wider the range of working temperature and the easier the control of the process would be.

In order to maintain the necessary degree of agitation of the bath and the rate of oxidation of the metalloids, the rate of carbon removal should be controlled at approximately 0·001 per cent. per minute during the course of refining. The time during which the refining should be completed could be calculated, therefore, from the loss in carbon. The refining time necessary for a carbon drop of 0·2 per cent. became

$$\frac{0{\cdot}2}{0{\cdot}001 \times 60} = 3{\cdot}3 \text{ hours.}$$

The rate of oxide feed could be adjusted to give the necessary output, depending on the hot-metal requirements of the open-hearth plant, but it should be kept at a minimum in order to prevent a sudden rise in the iron content of the slag, which would cause a vigorous bath reaction and a large drop in carbon. During the early stages of refining, however, when the silicon was being oxidised, and the bath temperature was rising fairly rapidly, a greater rate of oxide feed was possible, if not necessary, to help to flux the lime additions. The amount of oxide to be fed into the furnace during this period could be gauged from the silicon content of the iron. In certain circumstances it might be necessary to add unrefined iron to the refined mixer metal after having withdrawn some of the latter for steelmaking, and to repeat this procedure periodically, according to the supply of iron from the blast furnaces and the demands of the open-hearth furnaces. If a mixer output of 20 tons per hour were required, the oxide could be added at the rate of 13·5 cwt. per hour, after the first 150 tons had been refined.

In the case of high-phosphorus iron, of the order of 2 per cent. phosphorus, it would be necessary to carry out the refining in two or three stages, whereby the phosphorus content was reduced by approximately 0·6 per cent. in the first stage, and, after slagging off, a further stage was built up and more phosphorus removed. Subsequently, the refining might be carried on continuously by adding more blast-furnace iron periodically, but the refining time would depend largely on the permissible carbon drop and the amount of phosphorus to be removed.

Dr. T. P. Colclough, who opened the discussion, said that, in this country, we were faced with demands for higher and higher qualities of steel, for which we had only a limited supply of raw materials of the necessary purity. We were able to produce three grades of pig iron; that which contained high phosphorus, in the neighbourhood of 1·6 or 2 per cent.; that which had phosphorus in the neighbourhood of 0·6 to 0·7 per cent.; and that which had phosphorus in the neighbourhood of 0·06 per cent., or less. We were desperately in need of a pig iron which had a range of phosphorus of the order of 0·2 to 0·3 per cent., in order to enable the necessary slag conditions to be established in the furnace that would give low phosphorus and sulphur contents in the steel. The paper constituted an effort to show the range in which steel men could hope to refine the higher-phosphorus pig irons available and make them suitable for the manufacture of the higher grades of steel.

Mr. N. H. Bacon said that there was no doubt that high-phosphorus iron, the 1·5 to 2 per cent. grade, could be, and was, successfully treated in large tilting furnaces producing both steel and fertiliser slag, but it was open to doubt whether the use of phosphoric pig was justified, on economic grounds, in a cold-charged fixed furnace, when other material was available. He believed that it was more economical to employ hematite, even at a greater price, than to use phosphoric iron, but the paper opened up the prospect of getting a metal of 0·2 per cent. phosphorus which would be a very suitable alternative to the 1·5 per cent. phosphorus grade of iron. It had long proved advantageous to give the blast-furnace metal some preliminary treatment before it was introduced into the open-hearth furnace. The mixer had been developed into a semi-refining furnace and if it could be further improved, on the lines suggested by the author, its value as an aid to increased steel production would be very greatly enhanced. Mr. F. L. Robertson, who spoke next, stated that the quantitative chemistry of phosphorus elimination had been put on a firm foundation only within the last 15 years, and the important matter brought forward by the author, namely, the velocity of the carbon reaction or the carbon elimination at low temperatures was hardly ever discussed among steelmakers. He wondered whether the author was not being a little too bold in going straight to a 150-ton furnace. He suggested that the experiment should be made and the author's calculations tested on a small or workshop scale.

In a brief answer, Mr. Kerlie said that, obviously, if refining were to be carried out, the higher the carbon in the iron at the commencement of operations, the better it would be. It might be possible to add some carbon, in the form of coke breeze, to the blast-furnace iron as it passed into the ladle. It might be possible even to add more carbon to the metal before carrying out the refining process. In answer to Mr. Robertson, there was one great advantage in using a 150-ton furnace and carrying out the experiment on a large scale, and this was that the errors, if any, might be small in comparison. If the furnace were available, he did not think the experiment would be an expensive one. If the required object could not be achieved, it could be guaranteed that some dephosphorisation would take place. At all events, the material would not be lost; it could be used to carry on the practice as before.

The President then thanked the authors of all the papers for their contributions and declared the meeting closed. A vote of thanks to Dr. Desch terminated the proceedings.

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Convention of the Incorporated Municipal Electrical Association.—It is announced that the 1948 Convention of the Incorporated Municipal Electrical Association will be held at Eastbourne from Monday, June 7, to Friday, June 11.

## LAUNCHES AND TRIAL TRIPS.

M.S. "SALINAS."—Single-screw cargo liner built and engined by Messrs. Harland and Wolff, Limited, Belfast, for the Pacific Steam Navigation Company, Liverpool. Main dimensions: 440 ft. by 62 ft. 6 in. by 30 ft. 9 in.; gross tonnage, 7,000. Harland-B. and W. eight-cylinder two-cycle double-acting oil engine. Trial trip, November 17.

M.S. "KANTARA."—Single-screw cargo vessel, built and engined by Messrs. Harland and Wolff, Limited, Belfast, to the order of the Moss Hutchison Line, Limited, Liverpool. Main dimensions: 345 ft. by 52 ft. by 32 ft. 6 in. to shelter deck; gross tonnage, about 3,350. Harland-B. and W. six-cylinder four-cycle single-acting Diesel engine. Trial trip, November 20.

MOTORSHIP.—Diesel-engined vessel, built by Messrs. A. and J. Inglis, Limited, Glasgow, for the Irrawaddy Flotilla Company, Limited. Gross tonnage, 100. Launch, November 20.

S.S. "BOCA MAULE."—Single-screw vessel for the carriage of coal or iron ore, built by Messrs. William Gray and Company, Limited, West Hartlepool, for the Compañía Carbonifera y de Fundición Schwager, Valparaiso. Main dimensions: 415 ft. by 57 ft. 6 in. by 32 ft. 6 in. to upper deck; deadweight capacity, about 9,000 tons on a draught of 25 ft. Triple-expansion engine supplied by the Central Marine Engine Works of Messrs. William Gray and Company, to give a service speed of 10½ knots. Launch, November 27.

M.S. "MARIE MAERSK."—Single-screw tanker built by the Furness Shipbuilding Company, Limited, Haverton Hill-on-Tees, to the order of Messrs. A. P. Møller, Copenhagen. Main dimensions: 496 ft. by 67 ft. 6 in. by 36 ft. 5 in. to upper deck; deadweight capacity, 16,000 tons on a draught of 29 ft. Six-cylinder single-acting two-cycle Diesel engine of 4,850 brake horse-power, supplied by Messrs. Burmeister and Wain, Copenhagen, to give a speed of about 13½ knots on trial. Launch, November 27.

S.S. "POUL CARL."—Single-screw general cargo vessel, built by Messrs. S. P. Austin and Son, Limited, Wear Dockyard, Sunderland, for A/S Dampskibsselskabet "Heimdal," Copenhagen. Main dimensions: 307 ft. by 45 ft. by 20 ft. 3 in. to main deck; deadweight capacity, 3,400 tons on a draught of 19 ft. 1 in. Triple-expansion engine of reheat design supplied and installed by the North Eastern Marine Engineering Company (1938), Limited, Sunderland, to give a service speed of 13 knots. Trial trip, November 27

S.S. "SURAT."—Single-screw cargo vessel, with accommodation for 12 passengers, built by Messrs. Vickers-Armstrongs, Limited, Walker-on-Tyne, to the order of the Peninsular and Oriental Steam Navigation Company, London. Main dimensions: 490 ft. by 67 ft. by 43 ft. to shelter deck; deadweight capacity, 10,750 tons on a draught of 29 ft. 6 in. One set of single-reduction geared turbines developing 13,000 shaft horse-power, to give a service speed of 17 knots, constructed by Messrs. Vickers-Armstrongs, Limited, Barrow-in-Furness. Launch, November 28.

S.S. "ERIK BANCK."—Single-screw cargo vessel built by Messrs. William Gray and Company, Limited, West Hartlepool, for Erik Bancks Rederi A/B, Helsingborg, Sweden. Main dimensions: 310 ft. by 46 ft. 10 in. by 27 ft. 10½ in. to shelter deck; deadweight capacity, about 3,500 tons on a draught of 19 ft. Triple-expansion engine supplied by the Central Marine Engine Works of Messrs. William Gray and Company, to give a service speed of 12 knots. Launch, November 29.

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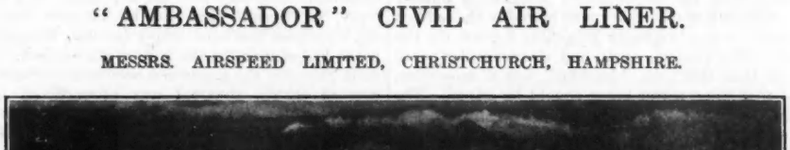
EXHIBITION OF ELECTRONIC INSTRUMENTS.—Messrs. Cinema-Television Limited, Worsley Bridge-road, Lower Sydenham, London, S.E.26, have arranged to hold an exhibition of a range of their Cintel electronic instruments, which will be held at Brettenham House, Lancaster-place, Strand, London, W.C.2, from January 20 to 31, 1948. Among the exhibits will be a detector for foreign metal objects in food products, textiles, plastics, etc., travelling on a conveyor; and a counter with a capacity of 30,000 per minute. Some new oscilloscopes, and other electronic apparatus for scientific and industrial purposes, will also be shown.

15-MW GAS TURBINE FOR TRAFFORD POWER STATION.—The Stretford and District Electricity Board has been directed by the Central Electricity Board to install a 15-MW gas turbine in their Trafford power station. This set, which will be the first of its kind in the country, is to be manufactured by Metropolitan-Vickers Electrical Company, Limited, Trafford Park, Manchester, 17, and will operate on the open-cycle principle, burning fuel oil. The present installed capacity of the station, which is situated in a dense industrial area, is 60 MW, and a further 30 MW of steam plant is being commissioned. The restrictions imposed by the site, however, render the use of gas turbine plant particularly suitable for further extensions.

# "AMBASSADOR" CIVIL AIR LINER.

MESSRS. AIRSPEED LIMITED, CHRISTCHURCH, HAMPSHIRE.



## THE "AMBASSADOR" CIVIL AIR LINER.

SOME details of the Ambassador medium-range air liner were given in our account, on page 282, *ante*, of the Radlett Flying Display and Exhibition staged by the Society of British Aircraft Manufacturers during September of this year. As pointed out in our description, the machine flown at the display had been only just completed and, in the circumstances, its performance was highly creditable. Since the exhibition, however, the Ambassador has been employed on extensive flight testing and the photograph reproduced on this page, which was taken during the tests, gives a good impression of its attractive appearance. So far, the tests have been confined to the elimination of any handling faults which are generally present in any new design of aircraft, but a sufficient number of performance figures have been obtained from these preliminary trials to justify the publication of a summary of them. Before doing so, however, it may be as well to give a brief résumé of the main points of the aircraft.

The Ambassador has been built by Messrs. Airspeed Limited, Christchurch, Hampshire, to the order of the British Government and has been designed to meet the demand for an aircraft capable of carrying up to 48 passengers over short and intermediate stages of transcontinental routes. It is of all-metal construction with a usable length of cabin exceeding 48 ft., which permits several alternative seating arrangements. Basically, the fuselage is of circular cross section and the entire length, including the crew's and rear luggage compartments, is pressurised. The aircraft has a span of 115 ft. and an overall length of 80 ft. 3 in., while the overall height over the rudder, the highest point of the machine, is 18 ft. 10 in. It is powered by two Bristol Centaurus 631 engines, each of which gives 2,600 brake horse-power for take-off, but the engines are being developed to give a considerably higher take-off power and the structure of the machine has been designed to allow the maximum weight to be increased from the existing 47,000 lb. to more than 50,000 lb. when this greater power is available. Furthermore, the general layout has been planned so that propeller turbines may be installed at a later date. A tricycle undercarriage of the duplex-wheel type is fitted and this is retracted hydraulically, the power being supplied from a hydraulic accumulator charged continuously by an electrically-driven pump, the main legs of the undercarriage retracting into the engine nacelles while the front wheel, which is steerable, retracts into the nose of the machine.

In the main, the flight tests, as previously mentioned, have been confined to improving the handling characteristics of the machine, and, so far, rudder and aileron loads have been reduced progressively. Nevertheless, a certain amount of flying time has been devoted to the important subject of asymmetrical control and its subsidiary problems, and the stage has now been reached at which it is possible for the pilot, under simulated take-off engine-failure conditions, to hold the aircraft down to minimum speeds of less than 110 miles an hour, which is 16 miles an hour lower than the safety speed on which the estimated emergency take-off figures were based. When flying at an all-up weight of 33,000 lb., a single-engine rate of climb of 770 ft. a minute has been recorded. This figure was obtained at 4,500 ft. when using maximum rich-mixture power with the propeller of the "dead" engine feathered and it compares well with the original estimate of 740 ft. a minute under the same conditions.

When test conditions permitted, some performance figures were obtained. It should be emphasised, however, that these figures are complementary to the main purpose of the tests, namely, the improvement of the handling characteristics, and, furthermore, represent a mean of the results obtained from time to time during the tests. Nevertheless, at an all-up weight of 33,000 lb. and a boost of 25 in. of mercury, the average speed proved to be 232 miles an hour at an altitude of 10,000 ft., whereas the performance under these conditions was estimated at 233 miles an hour. With the same all-up weight and operating at the same altitude but with a boost of 30 in. of mercury, the average speed rose to 250 miles an hour against an estimate of 251 miles an hour. When the all-up weight was increased to 36,000 lb. and the boost to 35 in. of mercury, the average speed at an altitude of 5,000 ft. was 264 miles an hour, compared with the estimate of 267 miles an hour. In each case, these figures were obtained with the weakest mixture.

A remarkable feature of the results is the closeness of the estimated figures to those actually obtained. The prototype aircraft, however, is carrying a certain amount of external test equipment, and the crew entry door at present is of a temporary parachute-exit type; these two points alone add considerably to the drag of the aircraft. It may be assumed with safety, therefore, that the standard aircraft will show an improvement on the estimated performance figures. Even as they stand, the performance figures are satisfactory and compare more favourably with the calculated speeds than is usually the case.

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## TRACK RECONDITIONING AND LIGHTING ON THE SOUTHERN RAILWAY.

WHEN permanent way is laid on a rock or other firm foundation, comparatively little attention is needed to keep it in good order, but when the track is carried over clay it not only requires far more attention, but conditions tend to become progressively worse, and a situation is reached when the usual rectification is beyond the capacity of a normal maintenance gang. In these circumstances, the unstable subsoil has to be removed for such a depth and distance as may be found necessary and replaced by material possessing better bearing properties, the process being known as "blanketing." It is understood that the first instance of this operation being carried out by the Southern Railway Company occurred some 12 years ago, when about half a mile of track at Hildenborough, between Sevenoaks and Tonbridge, was reconditioned by this process.

A similar operation was carried out recently on the main lines of the Western Section at Clapham Junction, where about a quarter of a mile of track near the station was blanketed, the work being completed in five week-ends. This involved the excavation of the clay subsoil to a depth of 4 ft. below rail level, the unloading and

laying of 900 tons of stone dust, 600 tons of precast concrete slabs, and 1,000 tons of track ballast; the operation was carried out by 40 men per shift, working day and night, with mechanical equipment. Including the excavated soil, an average of 40 tons per hour of various materials were handled, while trains were passing in close proximity. In this case, and in order to complete the work in the shortest time possible, concrete slabs were used instead of filling composed wholly of stone dust, and normal traffic was restored on each Sunday evening.

Another instance of blanketing, which we had an opportunity of inspecting recently, has just been completed at Paddock Wood station, on the main lines carrying the boat expresses between London and Dover. Here, when the railway was built a hundred years ago on marsh land, the ground level was raised by filling with weald clay, but under modern conditions of faster and heavier trains, the filling deteriorated and blanketing became essential. An extensive soil survey indicated that excavation to a depth of 5 ft., for a length of some 1,000 ft. under both the up and the down lines, would be necessary, and about 7,000 tons of clay have been removed and replaced by an equal volume of more stable material consisting of quarry waste and standard track ballast, the latter being laid to a thickness of 2 ft. As there are four tracks through the station (two main lines and two slow platform lines), it was possible to close the affected main lines for the required time and to divert the main-line trains over the platform lines without causing undue delay to traffic, but it was also necessary to make considerable temporary alterations in the junction to Maidstone West and extensive modifications to the signalling system.

The requirements in mechanical plant and materials were supplied in co-ordination with the similar work in hand at Clapham Junction, and in this connection it is interesting to note that, as the demand for the quarry waste was greater than that which could be provided currently by the Company's quarry at Meldon, near Okehampton, a stock was built up on the site before work commenced, so as to avoid holding loaded wagons. The plant employed on the work included two mechanical excavators, a roller for consolidating the stone dust, a grab for loading the wagons, and a Swiss ballast-tamping machine, which was supplied for experimental and demonstration purposes. This machine, which is self-propelled and complete with a separate parking platform to facilitate removal from the track when required, is manufactured by Messrs. Matériel Industriel S.A., Lausanne.

It may be mentioned here that an experiment in lighting is being made in the company's marshalling yards at Hither Green, in order to provide more effective illumination than that now supplied by numerous lamp posts spaced between the sidings. In the new system light is provided by a concentration of high-power lamps, placed at a much greater height than usual, and it has been developed from a previous experiment in which 20 powerful lamps were suspended from a barrage balloon 150 ft. above the ground. This experiment showed that elevated lighting gives much better results than single-point illumination from posts, and also has the advantage that, depending upon the area to be lighted, only a few lamp towers are required and the obstruction caused by a considerable number of lamp posts is eliminated.

The present trials are being carried out with groups of high-power lamps mounted in various arrangements on top of a temporary tower 150 ft. in height, constructed of tubular scaffolding and erected by Messrs. Mills Scaffold Company, Limited, Hammersmith. Four separate groups of lamps, which can be operated independently, have been assembled for test and demonstration. They consist of :—(*a*) Four tungsten lamps, each of 2,000 watts, in vitreous-enamel dispersive reflectors; (*b*) eight tungsten lamps, each of 1,000 watts, in vitreous enamel R.L.M. reflectors; (*c*) eight mercury discharge lamps, each of 400 watts, mounted horizontally in mirrored reflectors, giving a maximum beam at 45 deg., and (*d*) eight mercury-discharge lamps, each of 650 watts, mounted vertically in dispersive vitreous-enamel reflectors. The range of illumination at ground level can be varied from 0·5 to 2·5 foot-candles in the neighbourhood of the tower, and up to 0·03 foot-candle at a radius of 400 ft.

The siting of the two or three lamp towers required would be arranged so that the main beams of light are projected along the middle lines of the "fans" of sidings, so as to provide maximum lighting between the rows of sidings and so reduce the amount of shadow thrown by the wagons. The light and dark patches which occur with normal lamp-post lighting are eliminated, and an obvious benefit from improved illumination is that shunting operations can be conducted with greater safety and speed. If this scheme should be adopted, a special steel mast would be designed and the lamps would be suspended from pulley arms with control from the ground, in order to provide a means for easy maintenance and for adjustments in height to suit atmospheric conditions.

## LABOUR NOTES.

DISCUSSING the Government's record to date—which he regards as, on the whole, satisfactory—Mr. Beard, the general secretary of the United Patternmakers' Association, says in the latest issue of the organisation's *Monthly Trade Report*, that one of its mistakes was failure to put forward, two years ago, a nationalisation plan for all industry—"a target which would have been a rallying call to all workers—for, after all, it was they who put them in power and not those who believed in unrestricted private enterprise." "We, in the engineering industry," he goes on, "saw clearly long before the Labour Government was elected, the difficulties which would arise from an unbalanced economy. It was apparent that, with the loss of interest from overseas investments, exports would have to increase if our standard of living was to be maintained. A report on our industry was issued by the Union leaders, dealing with the need for mechanisation in every industry, and submitted to the Government. It is too long to quote here, but it is now obvious to everyone that generating sets, mining and modern textile machinery—to mention only a few products—are vitally necessary."

"Production by harder work," he continues, "may ease a temporary difficulty, but it is not a solution. Production must steadily increase over the years and machinery must do the job. Given a steady development of mechanised production, not only will output increase and goods become cheaper, but wages will increase too, and conditions improve. Our immediate problem, however, is to increase production with all the means now at our disposal. This means harder work. It means also that increased wages must be related to increased production; otherwise, prices will rise, savings will be reduced in value, and we will find ourselves in an inflationary spiral which might spell disaster."

"It is comparatively easy," Mr. Beard says further on in his notes, "for those in the more essential industries to take official or unofficial action to exact increases for which no corresponding effort in production is made; but this can only be done at the expense of the nation or the community. It is not right that in this time of crisis, some in comparatively well-paid sections of industry, should take advantage of the nation's need to exact highly favourable wages and conditions which they could not obtain in the normal way, and certainly not under any other Government. While one can agree that those engaged in the less congenial occupations which are essential should have consideration, there should be a reasonableness in the matter. The engineering industry has exercised great restraint and is entitled to expect others to do the same."

"There has got to be," Mr. Beard declares, "some clear thinking and unified action if we are to save the results of many years of trade-union effort. We obviously cannot complain of the action of others opposed to our views, if we, as a trade-union movement, cannot put our own house in order. Stability of wages and prices must be secured if only for a limited period, and an all-out effort made to increase production; failure to do this may result in Government action which will lead to friction, or, worse still, to a change of administration . . . A knowledge of the importance of workers as producers must bring with it a realisation of the responsibility involved."

In October, 77 patternmakers were admitted to membership of the United Patternmakers' Association, making the total membership 15,328. The number of superannuated members was 851. During the month 31 members were paid unemployment benefit and 211 members sick benefit.

Mr. Tom Williamson, M.P., the general secretary expresses the opinion, in the journal of the National Union of General and Municipal Workers, that suggestions to the effect that there should be a definite policy designed to control wage demands should be opposed. "The unions," he writes, "do not, and will not, take the view that a solution can be found by throwing a spanner into the wage-negotiating machinery. During the war, the unions were trusted by the Government and the country to use the voluntary machinery of wage negotiation with prudence, moderation, and restraint. And they did so—the Government itself acknowledges this in a statement emphasising the value of the voluntary machinery and the results it obtained during the difficult years of war. Personally, I am convinced that any departure from this standpoint will be disastrous for the Government, for the unions, and for the country."

Replying to Mr. Vernon Bartlett, the Independent Member for Bridgwater in the House of Commons last week, Mr. Isaacs, the Minister of Labour and National Service, said that about 6,500,000 working days had been lost in the United Kingdom since VE day through industrial disputes. In the corresponding period after November, 1918, 89,500,000 days were lost. Mr. Bartlett asked if the Minister would consult his colleagues on the front bench with the object of seeing that these figures were published widely.

Replying to a question by Mr. G. O. Roberts, the Labour Member for Caernarvon, Mr. Isaacs said that he hoped to have available about the middle of December, the results of the operation of the Control of Engagement Order. During the four weeks which ended on October 29, 101 directions had been issued, including 91 in respect of coal-mining and agriculture which were already covered by a Control of Engagement Order before October 6. Thus, only 10 directions had been issued as a direct consequence of the new Order during this period. In none of these cases were proceedings for non-compliance contemplated.

The General Council of the Trades Union Congress considered, at its meeting on Wednesday last week, a report of its Special Crisis Committee on the subjects of wages, subsidies, profits, and price control. The committee did not make any recommendation, but, at some length, gave results of its interviews with Ministers. The Council instructed it to continue these conferences with Ministers, and to report again, if possible, with a recommendation. If the Council approves, it will, it is understood, circulate copies of the report to members of the executive councils of its affiliated unions, and, later, it is believed, will call a meeting of executives to consider the whole position.

The General Council also instructed its special Committee and the International Committee of the Trades Union Congress to make a joint report on the whole question of American aid to Europe. It reacted favourably, though cautiously, it is stated, to the suggestion of the American Federation of Labour that a special conference should be called of representatives of trade-union movement in countries interested in the Marshall plan.

At a meeting last week, delegates representing about 76,000 employees of the London Passenger Transport Board decided to apply for a wage increase for all grades engaged on the central bus, tram, and trolley bus services and also the country services. Garage staffs who are members of the Transport and General Workers' Union will be included in the claim which is to be prepared by a sub-committee and will be submitted to the London Passenger Transport Board in about a fortnight.

Delegates of the Union of Post Office Workers decided at a conference in Blackpool on Friday last week by 1,619 votes to 1,167 to accept the wage increases offered by the Postmaster General. The changes, it is estimated, will cost 5,000,000*l.* a year. The original claim of the union was for an increase in the minimum rates of adult workers and a re-adjustment in the scale of increments to ensure that minimum rates were reached at the age of 21. It would have cost about 12,000,000*l.* a year. The employees affected by the increases now agreed to, include postmen, sorters, telephone operators, counter clerks, and others in the operative grades.

Commenting upon the agreement with the Union of Post Office Workers at a meeting of the Civil Service Clerical Association, Mr. L. C. White, the general secretary, claimed that the Government was giving preferential treatment on wage agreements to unions affiliated to the Labour Party.

The Evershed Committee in its second report on the cotton textile machinery industry states that a programme of re-equipment on the scale suggested by the cotton working party, and in the relatively short time envisaged, could not be achieved by the existing manufacturers. "Having carefully considered," it adds, "all other possibilities, we are satisfied that the only way in which production on the scale, or in the time envisaged, would be, by means of a scheme of intensive flow production on the lines adopted during the war for munitions. Such a scheme, the Committee say, would require, on the one hand, Government action of a far-reaching character with a view to providing the necessary factories, plant, equipment and labour, and, on the other, the fullest co-operation on adequate and fair terms of remuneration in the matter of management, design, and otherwise, of the existing automatic loom makers.

# CAUSES OF LOW DUCTILITY IN MILD STEEL.*

By PROFESSOR J. F. BAKER, O.B.E.

NORMALLY, mild steel—that is to say, steel with a carbon content of less than 0·20 per cent. C. and covered by B.S.S. No. 15—is regarded as a ductile material. It gives high elongation and reduction in area in a tensile test; it can be rolled, drawn and generally worked cold; it deforms under load with considerable absorption of energy. Fracture without previous measurable plastic deformation may occur, however, in certain circumstances. The conditions which have been found by previous investigations to lead to premature failure, particularly as they are likely to affect welded steel structures, are briefly discussed in the following summary.

Brittleness in metals is usually indicated by low elongation and reduction in area figures in a tensile test and by low energy absorption in a notch impact test. The first measures ductility under static conditions of loading; the second measures two properties, namely, notch sensitivity and velocity sensitivity. The path of the normal fracture in metals is across the crystal grains rather than between them. An inter-granular fracture is usually associated with some form of chemical attack. Two types of trans-crystalline fracture are recognised. One may be described as a shear fracture and is characteristic of most ductile metals under normal conditions; the other is a cleavage fracture, and this is characterised by absence of plastic deformation.

Very little is known about the conditions leading to fracture. Ductile metal crystals deform plastically by a process of gliding on those planes of greatest atomic density upon which the shear stress is highest, and in that direction in the glide planes represented by lines of closest atomic packing. Deformation begins when a critical shear stress is reached, depending on temperature, purity, etc., and the shear stress increases with the amount of shear, due to work-hardening. In the case of a normal polycrystalline metal, a combination of planes is required to maintain contact between the grains as they deform. When the increase in resistance to shear no longer compensates for the reduction in area of the test-piece, or when discontinuities arise which lead to local high stress concentrations, the material fractures. If fractures occur on the glide planes, the plane of fracture is often at 35 deg. to 45 deg. to the direction of principal stress. It is usually fibrous or silky in appearance, owing to the distortion that has taken place on the glide planes. A considerable amount of energy is absorbed during the deformation.

Fracture does not always occur on the glide planes, and may or may not be preceded by plastic deformation. Crystallographers have long been familiar with the method of breaking even the hardest substances by cleavage. Owing to the absence of, or small amount of, plastic deformation, the plane of fracture is bright and polished. It occurs when the stress normal to the plane reaches a critical value, and in polycrystalline metals the plane of fracture is perpendicular to the direction of principal stress. The energy absorbed to fracture is small. Cleavage in crystals is generally started by means of a notch and pressure along the direction of the particular crystal plane upon which separation takes place. Fracture will only take place on certain specified planes. The work done in separating plates of mica has been found to be 1,500 erg per square centimetre in air and 20,000 erg per square centimetre in vacuo.

The crystal planes involved in these two types of fracture are usually crystallographically dissimilar. Owing to the small size of the crystals of most commercial steels, it is not always possible to distinguish between the two types of fracture when cleavage follows plastic deformation, or to determine the cleavage planes by means of X-rays. The abrupt change in direction of the fracture as it passes from crystal to crystal, imparts the characteristic appearance to the cleavage fractures, in contrast to the silky, fibrous shear fractures.

Sir Charles Inglis's calculation of the stress at the ends of an elliptic hole showed that, in the case of a natural crack of atomic dimensions situated perpendicular to a tensile stress, the stresses might be very high. A. A. Griffith sought to explain the discrepancy between the calculated and observed strengths of materials by postulating the presence of fine cracks, chiefly on the surface. P. Ludwik first pointed out that there is a state of triaxial stress at the bottom of a crack or notch which might effectively prevent shear and facilitate cleavage. Ludwik's work led to a vast amount of work on the influence of notches in producing non-uniform stress and strain. The presence of discontinuities, whether they exist in any solid initially or develop as a result of plastic deformation, are held to account for the change in properties accompanying plastic deformation and leading to fracture.

It may be assumed for the present that the composition of the steels, judged by ordinary standards of analysis, is satisfactory. High carbon content will lower the ductility and silicon is known to make iron and steel more susceptible to cleavage. Small amounts of other elements may be more important than they appear to be from existing information. A very complete investigation of the mechanical properties of steels from different sources, made by S. Epstein, suggests that traces of impurities not usually determined may be of great importance in producing a cleavage fracture under certain conditions.

The following causes of low ductility have been considered: prior plastic deformation; changes in constitution and structure; low temperature; high rates of straining; large dimensions of test-pieces; and corrosion.

From what has been said previously, it is clear that a metal which has been plastically deformed already can only suffer a limited further amount of deformation. The total deformation depends to some extent on the conditions under which it is carried out, since, if the metal at any time becomes non-uniform in cross-section, fracture may occur prematurely. It is for this reason that the maximum amount of work-hardening of which a metal is capable is rarely attained in a tensile test, and far higher values in the ultimate breaking stress and hardness are possible in the case of rolling, drawing, etc. The shapes of the stress-strain curves of a mild steel after various degrees of reduction by rolling are shown in Fig. 1, herewith. The work has more than doubled the ultimate breaking stress, with an accompanying serious loss in ductility.

To obtain work-hardening, it is essential that the deformation be carried out below a certain temperature. At high temperatures, there may be no marked yield point and the metal may flow under very small loads, under almost constant stress. In Fig. 2, herewith, are plotted stress-strain curves for normal tensile tests on samples of plate upon which experiments have been carried out in the Cambridge University Engineering Department. It will be noticed that the extension between the beginning of the yield and the ultimate is about 20 per cent. Except where plates are subject to severe local distortion in shearing, flanging, or cold bending, the potential ductility of the metal should ensure that the maximum stress of the steel is never reached.

It is possible to break a metal by repeated alternating loads without any appreciable change in dimensions; nevertheless, deformation and work-hardening occur in the same way as under conditions of static loading. This has been shown by the appearance of slip bands on the surface of the crystals, by means of X-rays, and by mechanical tests on material which has previously been subjected to alternating stresses. Slow reversals of stress may be more damaging to the crystal structure than rapid alternations. The endurance limit under alternating stresses is very seriously lowered by roughness or irregularities of the surface and by sudden changes in dimensions. Such faults result in stress concentrations, and fracture is usually initiated by the formation of a crack in these regions. The cracks may proceed slowly for some time and have a silky appearance. When the stress on the unbroken part becomes too high, it may fracture suddenly, sometimes by means of a cleavage fracture.

Static tensile notch tests which have been made on work-hardened metal appear to show that the strength first rises and then falls with increasing amounts of previous deformation. The interpretation of these results is still in dispute. The energy to fracture in notch impact tests is less in previously worked metal. All notch tests, even when the fracture is mostly crystalline, have a fibrous zone at the bottom of the notch where most of the energy to fracture in impact is absorbed. Fig. 3, herewith, which is due to Schuster, illustrates this point. It shows a round notch test-piece broken in impact. The point A on curve corresponds to change from fibrous to crystalline fracture. Similarly, in slow bend tests, alternate zones of fibrous and crystalline fracture coincide with the absorption of more or less energy in load-deflection curves (Fig. 4). If it may be assumed that the material at the base of the notch always reaches a condition represented by that of the true stress at fracture of the metal in tension, the already work-hardened metal has not so far to go before reaching this state. Less energy is absorbed in starting a fracture and, if the final fracture is crystalline, still less energy is required to break.

It is possible to sum up the effect of prior plastic deformation as a condition leading to brittleness in structural steels in the following way. Unless the material is in such a condition that its unsuitability would easily be detected by the normal methods of testing, its capacity for deformation is such that it would be unlikely to break without first undergoing some change of shape. Failure due to fatigue is possible. A crack, once formed, may act as a notch and start a cleavage fracture. Plastic deformation

* Appendix to the paper on "The Problem of Brittle Fracture in Ship Structures," presented by Professor J. F. Baker, O.B.E., at the Conference on Brittle Fracture in Mild-Steel Plates, held at Cambridge on October 26, 1945, and printed on page 532, of this issue. Abridged.

## LOW DUCTILITY IN MILD STEEL.

Fig. 1.

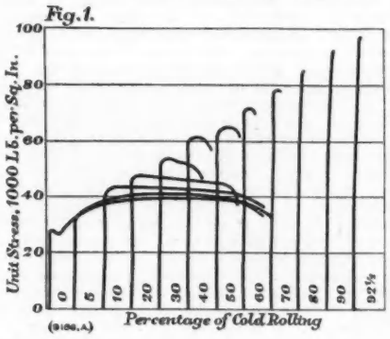



Fig. 2.

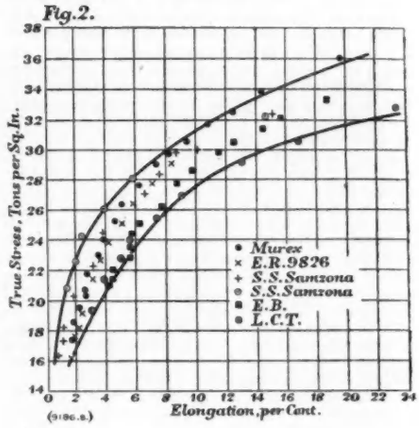



Fig. 3.

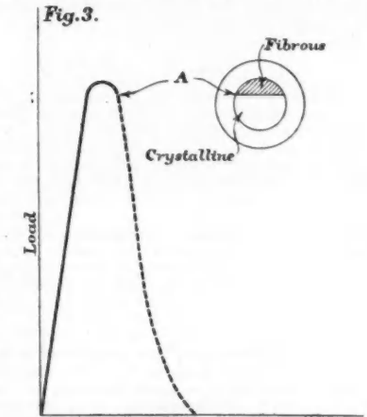
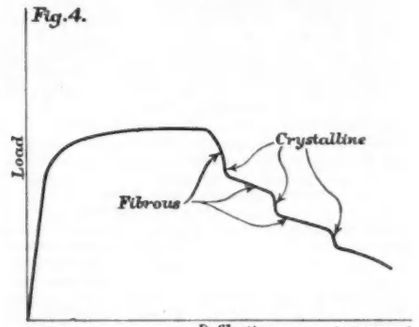



Fig. 4.



# LOW DUCTILITY IN MILD STEEL.

Fig. 5.

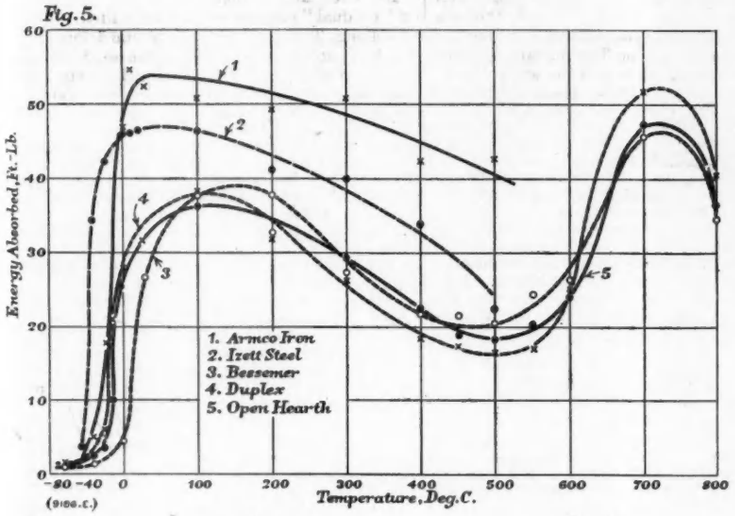



Fig. 6.

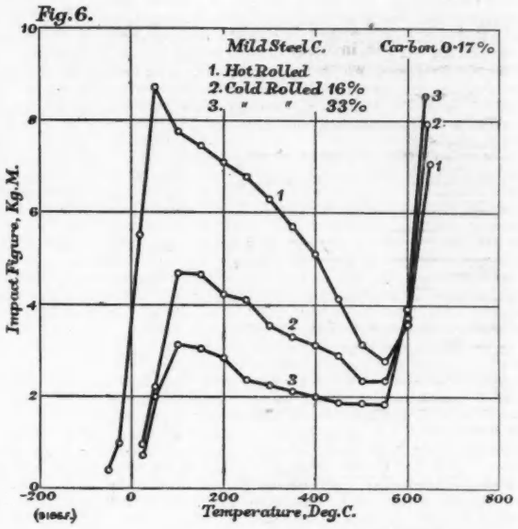



Fig. 7.

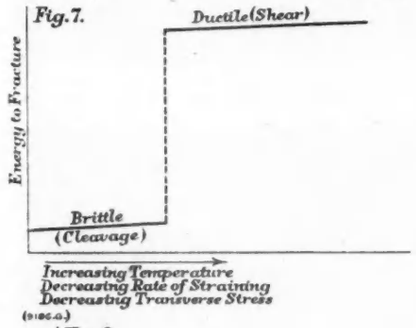



Fig. 8.

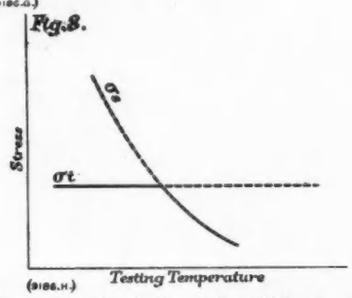
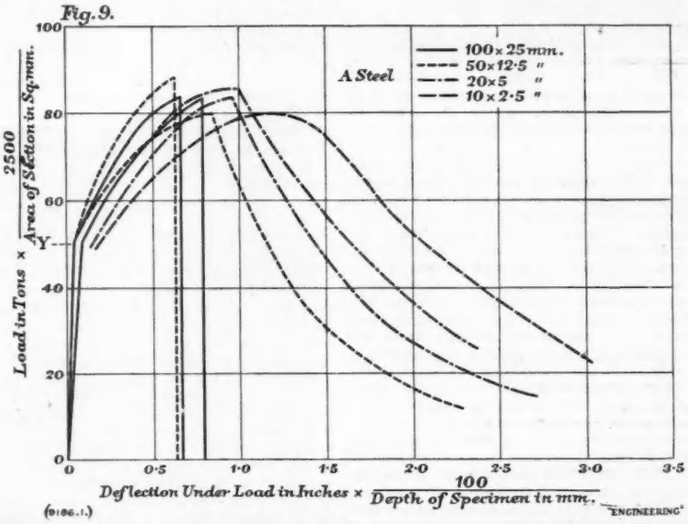



Fig. 9.


A Steel
100 × 25 mm.
50 × 12·5 "
20 × 5 "
10 × 2·5 "
Load in Tons × 2500 / Area of Section in Sq.mm.
Deflection Under Load in Inches × 100 / Depth of Specimen in mm.
ENGINEERING

produces internal, elastic strains which may lead to early fracture. Bending in notch tensile and impact has been found to weaken the metal and to change the character of the fracture.

Changes in constitution and structure, due to cooling from a high temperature, at a rate too rapid for equilibrium conditions to be attained, may cause increase in strength but loss of ductility. This may take one of two forms.

A chilling effect is produced when the molten metal from the electrode in welding comes in contact with the cold plates. The temperature of the plate metal is also raised for a short time above the critical range and rapidly cooled by the heat flow away from the weld. Brittleness may thus be produced in the immediate vicinity of the weld, specially if the carbon content is high. Hardness measurements and impact tests on welds and plates have been made to determine the seriousness of this effect which may lead to the formation of cracks near the weld. These might then spread to other parts of the plates.

Precipitation, or strain-age-hardening, is attributed by various workers to the separation of carbides, oxides, or nitrides, which are held in supersaturated solution in the ferrite. Plastic deformation, followed by resting or heating at a low temperature, 100 to 200 deg. C., results in the recovery of the elastic properties of the steel, the formation of a new yield point, which may be as high as the ultimate breaking stress, and a serious loss in ductility. A cold-worked steel may be "stabilised" by heating for long periods at 100 deg. C., after which it will no longer strainage-harden. This is not the case in a somewhat similar form of brittleness, for example, "blue brittleness," to which steels are subject at temperatures of from 200 to 500 deg. C. Like "cold-brittleness," to be discussed later, it has no permanent effect on the mechanical properties of the steel and only manifests itself at the temperature of the test. Steels tested in the blue-brittle range have low impact values and ductility in a tensile test, but higher tensile strengths. Brittleness due to any of the causes discussed above may arise in welded structures. The steel at some distance from all welds must pass through the blue-brittle range. Strain-ageing is also likely to occur, either as a result of plastic strains set up in the welding operation or on account of the plates themselves being in a cold-worked condition.

Tensile tests at progressively lower temperatures show a gradual rise in yield and ultimate strengths and decrease in ductility, although some metals retain much of their ductility even at −252·8 deg. C. (liquid hydrogen) and cadmium is ductile at −271·8 deg. C. Iron and mild steel, however, become brittle and may fracture with no extension. The temperature at which the change occurs varies with the steel. Hardness measurements at low temperatures show a gradual increase with fall in temperature.

The influence of low temperatures has been studied most fully in the case of notch tests. A very sharp fall in energy to fracture in impact tests occurs between normal room temperatures and sub-zero temperatures, depending upon the steel and the treatment it has received, as shown in Figs. 5 and 6, herewith. The fall in impact value is associated with a change in the fracture from a fibrous type to cleavage. Certain conditions, such as coarse grain, previous cold-work, sharpness of notch, tend to raise the temperature at which the change occurs. High manganese lowers the temperature range, and aluminium-killed steels appear to be slightly more satisfactory than semi-killed.

In connection with tests at low temperatures, the form of test and small differences in shape and dimensions of test-piece can have great influence on the temperature at which the change from a fibrous to a cleavage fracture occurs. Many of the test-pieces fracture in the heads at low temperature and the smallest defect on the surface may act as a notch. The effect of form of test on the energy absorbed in fracture at different temperatures and the corresponding shift in the change point, is well shown by N. Davidenkov and F. Wittmann. The change occurred at + 20 deg. to − 20 deg. C. in notch impact and at − 100 deg. to − 150 deg. C. in tensile impact with no notch, the change also being more gradual.

High rates of straining are considered to be comparable with low temperatures in affecting the ductility of steel and in producing a cleavage fracture. In unnotched bars, the yield stress may be nearly doubled, but the ultimate stress is little altered and there is a slight decrease in ductility measured by elongation in a tensile test. In notch tests, a high impact velocity may change a fibrous fracture to a crystalline type, with corresponding decrease in energy absorbed. A high strain rate and stress gradient at the base of the notch tend to bring yield point and ultimate closer, and so to make the relationship between strain rate and temperature closer. The connection is shown diagrammatically in Fig. 7, herewith, which is due to C. Zener and J. H. Holloman. This diagram would be equally applicable if, instead of ductile and brittle, one wrote fracture by shear and fracture by cleavage.

The conclusions to be drawn from the foregoing are that, at a given point, depending upon temperature, strain-rate or stress distribution, the shear strength of iron is equal to the cleavage strength and that, above

this temperature, cohesion forces are higher between the cube planes of the crystal than between the shear planes. Therefore, the metal deforms by shear. Below this temperature, the shear strength is greater than the cleavage strength and the crystal fractures by cleavage. Somewhat similar views have been put forward by A. F. Joffé, Davidenkov and Wittmann and are illustrated in Fig. 8, on page 549. The ratio of cleavage strength ($\sigma i$) of the material which is either independent of or depends only slightly on temperature, to its yield strength ($\sigma s$), plays the deciding part in determining the critical temperature of brittleness. It is apparently a fact that very little further decrease in energy takes place in impact tests as the temperature is lowered, after the sudden fall has occurred. Fig. 3 showed that, as soon as a cleavage fracture starts, the energy absorbed is very small; in fact, the elastic energy set free in the separation of the crystal plates may be sufficient to keep the fracture "going" at a high velocity. On the other hand, a shear fraction takes place at the maximum breaking stress of the metal, with considerable absorption of energy and at a rate determined by external conditions of testing.

The influence of large dimensions in a tensile test is slight. Instances of brittle fracture in mild-steel plate may be attributed to a notch effect rather than to the dimensions of the test-pieces. In slow or impact notch-bend tests, dimensions become increasingly important. Smaller test-pieces give higher values for energy absorbed than large ones, when geometrically similar. In slow bend tests, J. G. Docherty found that the slope of the load-deflection curves were the same up to the maximum, after which the large specimens failed suddenly with a crystalline fracture, while smaller test-pieces of the same material continued to absorb a considerable amount of energy and had a fibrous fracture (Fig. 9, on page 549). In impact, increase in width decreases the energy to fracture. In all these tests there is a fibrous ductile zone at the bottom of the notch and on the surface, even when the fracture as a whole is crystalline. Hence, the larger the proportion of surface to volume, the more energy is absorbed.

Corrosion may lead to premature failure by the formation of pits or by intergranular attack; both pits and cracks may then act as notches. A metal in a state of strain is more readily attacked by chemical reagents. The penetration of steels by solder under stress, by zinc during the galvanising of work-hardened steels, and the caustic embrittlement of high-pressure boilers may all be regarded as stress corrosion problems. Cracks and crevices not only weaken the metal, but promote further corrosion on the surface in their immediate vicinity. Alternating stresses accelerate the rate of corrosion, in the first place by breaking down any protecting layer and dislodging the products of corrosion, and in the second, by opening the crack and giving access to the corroding medium. The stress concentrations due to pits and cracks also lower the endurance limit; in fact, in cases of combined corrosion and fatigue, there may be no safe range of stress. Dr. H. J. Gough has made a point of the fact that the effects of alternating stress and corrosion are not merely additive, but the one accentuates the other. The cracks are not usually intergranular, although they may follow the crystal boundaries if impurities are segregated there.

There are many opportunities for the development of pits and cracks by corrosion in welded structures, particularly where they are in contact with salt water or spray. Cracks in the weld metal, or between weld metal and plate, are potential sources of trouble, as is cold work in any form due to cutting, flanging, bending or fatigue. Embrittlement of mild steel by hydrogen may lead to both intergranular and trans-crystalline fractures. While in an embrittled condition, the mechanical properties are sensitive to temperature variations and to notches.

To summarise: there are two ways by which steel may fracture. What is usually considered to be the normal method is by shear, preceded by plastic deformation. The other method is by cleavage, which is associated with high velocity of propagation and low energy absorption. The exact conditions necessary to start such fractures are still not determined.

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ELECTRIC FANS IN UNDERGROUND COACHES.—The London Passenger Transport Board have fitted a coach on the Bakerloo Line with an experimental set of four electric fans to circulate the air within the coach while the coach is running in the underground sections of the line. Owing to the limited headroom, it has been necessary to place the four blades of each fan in a space between the roof and ceiling, with the motor fixed underneath and projecting slightly into the interior of the coach. The fan draws air through an annulus round the motor, imparts a centrifugal motion to it, and blows it back into the coach through vanes around the periphery of the casing. Each motor runs at 520 r.p.m., and requires 30 watts at 50 volts.

## NOTES ON NEW BOOKS.

*The Alford and Sutton Tramway.* By GEORGE DOW. Locomotion Papers No. 1. The Oakwood Press, 30, White Horse Hill, Chislehurst, Kent. [Price 2*s.* 6*d.*]

THE sub-title of this pamphlet is explained by the fact that it represents the resumption of publication of the quarterly *Locomotion*, which had to be suspended at the outbreak of war in 1939. The steam tramway described had only a short life, from April, 1884, to December, 1889, but is of interest as being typical of a method of transport of which, at one time, great hopes were entertained, but which, on British soil, throve only spasmodically and in isolated cases. It connected the small Lincolnshire town of Sutton-on-Sea with the railway station at Alford, on the East Lincolnshire line of the Great Northern Railway, and was constructed by W. B. Dick and Company, the firm which afterwards became Dick, Kerr and Company, and eventually was merged in the English Electric Company. Mr. Dow, as he admits, had very little material to work upon, but he has made the most of it.

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*Great Loco Story.* By R. L. GREY. Quadrant Publications, 390, Wakefield-road, Huddersfield. [Price 2*s.* 7*d.*, including postage.]

THIS somewhat inadequate title should not be allowed to deter admirers of the work of the late G. J. Churchward, as chief mechanical engineer of the Great Western Railway from 1903 to 1922, from a careful perusal of this survey of the locomotives for which he was responsible and of his influence upon British locomotive engineering. His work, to quote the author's summing-up, "was based on simple design to meet practical requirements, no energy being wasted on revolutionary departures from the conventional form of the steam locomotive"; but "his standard components were the embodiments of principles that were a sure foundation for development for many years ahead." The booklet is illustrated with a series of neat line drawings of Churchward's engines, and contains also a great deal of dimensional and other data, conveniently arranged in tabular form.

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*Electricity and Fire Risk.* By E. S. HODGES, F.C.I.I., A.M.I.E.E. Second edition. Sir Isaac Pitman and Sons, Limited, Parker-street, London, W.C.2. [Price 15*s.* net.]

THIS book is written explicitly for the instruction of fire surveyors, particularly those preparing for the examinations of the Chartered Insurance Institute, and was published initially in 1934. The range of subjects treated is very wide, from wiring and power stations to electrostatic precipitators and lightning hazards. The section dealing with the electrical risks of fire-fighting appliances is especially valuable. This second edition has been brought up to date in many places, but it has not been extensively re-written, as may be seen by its more frequent reference to direct-current than alternating-current supplies, and the fact that it still uses quotation marks when referring to the grid. The chapter on theatre lighting is particularly dated; the reader will look in vain, for example, for a reference to the use of saturable reactors as dimmers. The author has much to say about the fire risks attendant on the use of oil in transformers and switchgear. Although their cost is not yet low enough to render wide adoption economically possible, it is hoped that in future editions, Mr. Hodges will treat of synthetic organic substitutes, such as the silicones. Despite the above criticisms, the book is an impressive collection of the sins of faulty installation and the neglect to which electrical installations are prone, particularly in shops and small factories; any surveyor who has studied these warnings and the description of sound practice which accompanies them, will be well equipped for his work. It is suggested that electrical engineers might do well to study this book; but, since familiarity breeds, if not contempt, at least a tendency to be blind to the faults of apparatus which continues to be serviceable, factory managers also might do well to learn its lessons.

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PETROL PRODUCTION IN THE UNITED KINGDOM.—In reply to a question by Mr. J. D. Murray in the House of Commons on Thursday, November 27, the Minister of Fuel and Power (the Rt. Hon. H. T. N. Gaitskell) said that the indigenous production of petrol, and the production from imported crude and process oils in the United Kingdom, amounted to 691,000 tons in 1946, compared with 276,000 tons in 1945. The figure for the period January to October, 1947, was 422,000 tons. During 1946, 114,000 tons of aviation spirit were also produced, compared with 411,000 tons in 1945 and 58,000 tons during the first ten months of 1947. The whole of the aviation spirit was produced at Billingham, where it was hoped there would be a substantial increase during 1948.

## THE MANUFACTURE OF CAST-STEEL BOMB-BODIES.*

By PERCY H. WILSON, O.B.E., M.I.Mech.E.

(*Concluded from page* 527.)

THE moulds were closed at the next station, the copes being lifted from the moulding machines by means of pneumatic double-armed radial pillar-cranes and placed on the drag. One man operated the crane, while two others guided the cope into position. It was located by means of two loose closing pins which entered bushed holes provided on opposite corners of the box. The pre-moulded runner bushes were fixed in position at the cope ramming stage, a certain amount of "bedding in" being required, which could be carried out more expeditiously with the box in this position. The cores were centred by three setting sticks and fixed in position with three oil-sand segment cores. They were then gauged before being clamped and moved forward for casting.

The casting platform had the equivalent length of eight boxes and was constructed to allow one heat to be cast without any movement of the conveyor. This permitted all other operations, such as placing of moulds on the conveyor, coring up, etc., to be carried out while the conveyor was stationary. The metal was delivered to the foundry in internal tea-pot spout ladles by a 7-ton electric jib crane, which lowered the ladle of steel on to a sand bed, where it was picked up by an overhead electric telpher crane. There were two 7-ton electric telphers in constant use, running on an endless track 192 ft. long.

During transfer from the converters, a certain amount of slag formed in the tea-pot spout and this was poured on the bed before the metal was taken to the casting platform. When two boxes of bombs had been cast, a sample for analysis was poured and a test-bar was cast in an oil-sand mould. This procedure was carried out for each heat cast, the heat number being stamped on the test-bar mould. The times of the receipt of steel in the foundry, the finish of the cast, and the number of bombs per heat, were recorded. A plate was hung on the first and last boxes from each heat and these were removed by the heat checker in the stripping bay, who marked each bomb with the heat and serial number, as soon as the cope was removed. The bombs were identified by this number through all subsequent stages of manufacture.

The core bars were withdrawn by means of overhead air hoists, suspended from a monorail, approximately two minutes after casting, and were placed on an overhead conveyor, which returned them to the core-bar wrapping station. The movement of the mould conveyor then carried the moulds into a fume tunnel where the fumes and gases were exhausted.

On emerging from the tunnel, the castings were stripped in a bay provided with five 5-ton electric overhead travelling cranes. The first of these was used to take off the copes, an operation easily carried out by the use of a specially constructed lifting bale incorporating a pusher which exerted pressure on the castings as the box was lifted. The copes were placed on jolt grids, from which the sand fell on to an underground conveyor belt 150 ft. long, which extended for the whole length of the bay, and delivered the sand, by way of an inclined belt 250 ft. long, into the used-sand storage hopper. The empty copes were then returned to the ramming station by a gravity conveyor which ran along the rear of the sandslingers.

The castings were removed by two further cranes, and placed in specially constructed bogies for transfer through cooling tunnels, each bogie containing four pairs of castings. The remaining two cranes were used to place the drags on jolt grids from which the sand fell on to the underground belt previously referred to. The empty drags were afterwards transferred by crane to a gravity-roller conveyor from which air hoists transferred them back to the sandslingers for ramming.

Special attention was paid to the problem of dust extraction at the mould knockout, by the provision of suction manifolds just below the grids. These communicated, by means of mild-steel ducts, laid beneath the foundry floor, with a group of three fans with dust separation plant, which were housed in a separate building adjoining the foundry. One fan and separator unit dealt with each knockout section, each fan being 6 ft. in diameter, and having a capacity of 25,000 cub. ft. per minute. The dust extracted at the knockouts was collected in storage hoppers, which discharged into railway wagons.

The stripped castings, which were placed in bogies in the stripping bay, were pushed through cooling tunnels, two of which were provided, by means of electrically operated screw-type pushers. The cooling tunnels

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* Paper entitled "Mass-Production Methods Applied to the Manufacture of Cast-Steel Bomb Bodies," presented at the 44th Annual Conference of the Institute of British Foundrymen, at Nottingham, on Wednesday, June 18, 1947.

# MANUFACTURE OF CAST-STEEL BOMB BODIES.

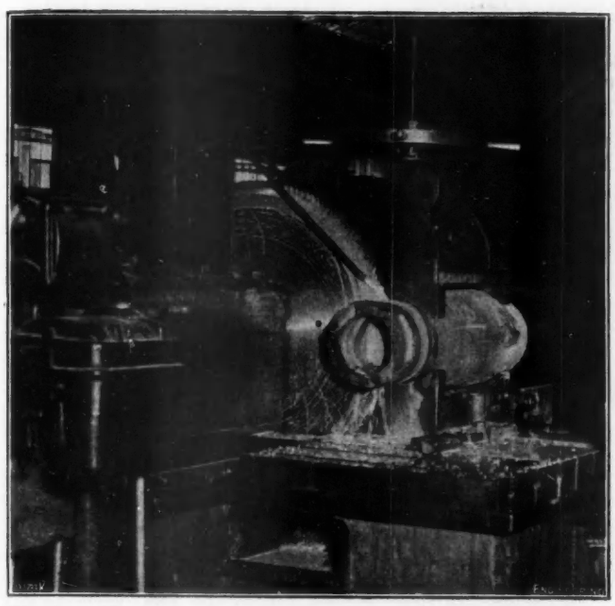

FIG. 10. SAWING OFF CASTING HEAD.

FIG. 11. SWING-FRAME GRINDING MACHINE.

FIG. 12. CASTINGS EMERGING FROM COOLING TUNNELS.

accommodated a total of 50 bogies, and the hot air exhausted from them was conducted, through suitably arranged ducting, to the preheating zone of the core-drying stoves, thereby effecting a considerable reduction in the consumption of gas in this section. Fig. 12, on this page, shows castings at the exit end of the cooling tunnels.

On emerging from the tunnels, the castings were transferred to the core knockouts, over which four 1-ton electric overhead travelling cranes were situated. Two of the cranes, one for each knockout, were used to unload the bogies, which were then returned to the stripping bay for reloading. The bombs were inverted over the knockout grids and the sand fell on a conveyor belt, which transferred it to a hopper outside the building for loading into railway wagons. The dust from this knockout was extracted by a plant similar to that for the mould knockout. There was, however, only one fan in this section with a capacity of 34,000 cub. ft. per minute.

The bombs, in pairs, were then suspended on an endless-chain conveyor and passed through shot-blast cabinets for cleaning round the ingate. The conveyor was routed to pass the ingate-cutting station where the bombs were removed by the third crane and laid on gantries. The ingate was cut off in 25 seconds by an oxy-acetylene burner, using a $\frac{1}{16}$-in. nozzle. Both oxygen and acetylene were piped to this point from a central plant outside the building. After separation, the bombs were delivered by the remaining crane to an electrically operated transfer bogie, which distributed them to the gantries serving the head cutting-off machines.

For head removal, there were five cold saws, 36 in. diameter, and four oxy-acetylene cutters with gear for rotating the bombs inside fixed burners. In the saws, one of which is shown in Fig. 10, on this page, the bombs were stationary and the saw blade was moved forward by hydraulic power according to the feed required. The average time taken (floor to floor) was 4·4 minutes in the cold saws and 3·75 minutes by the use of the flame cutters.

Following the head-cutting operation, the bombs were transferred on gantries to swing-frame grinders for the ingate area to be finished, this operation, illustrated in Fig. 11, taking an average time of 1¼ minutes. There were 10 grinders, each carrying a 16-in. wheel, driven by a 5-h.p. motor connected by Tex rope. The grinding wheel and motor drive were mounted on a steel chassis, which was slung from a handwheel chain block, which was free to travel on an overhead runway. The surface speed of the wheel was 9,000 ft. per minute. It was controlled by push-button conveniently situated to suit the position of the operator. A dust-collecting hood was attached to each grinder, with 6 in. diameter metallic tubing connected by overhead trunking to an exhaust fan and dust separator of 6,000 cub. ft. per minute capacity, situated outside the building. It is interesting to note that no chisels or pneumatic tools of any description were used in fettling.

After grinding, the bombs were passed along gantries to test tanks, where each bomb was tested under water at an air pressure of 40 lb. per square inch, nine tanks being used for this purpose. The bombs were rolled on to a pneumatically-operated ram, which lowered them into the water, where they were rotated slowly while a careful watch was maintained for leaks. At all stages subsequent to casting, inspection was carried out for casting defects, exterior and interior smoothness, wall thickness and body contour. Following testing, the bombs were transferred to inspection gantries running the full length of the bay. After inspection, they were cold-stamped with heat and serial numbers, loaded by an electric overhead travelling crane into lorries in batches of 40 bombs, and transported to the heat-treatment plant.

For heat-treatment, each casting had to be taken up to a soaking temperature of 950 deg. to 970 deg. C. and held there for 2½ hours, followed by slow cooling. If the usual type of batch annealing furnaces had been installed, very extensive plant would have been necessary to deal with the large output of castings. Advantage was taken of two existing continuous furnaces which were normally used in the production of spun-iron pipes, and a continuous annealing process was evolved. This again was an innovation which proved highly successful. The physical tests on test-bars, and the drop-hammer test on the bomb bodies, gave results well in excess of the requirements of the Ministry of Aircraft Production. This was a particularly good achievement when the high output is considered, the reason being that the construction and operation of the furnaces allowed each bomb to have what was in effect individual heat-treatment.

Each furnace was 90 ft. long and 21 ft. wide, and six channels of heat-resisting cast iron, equally spaced, ran the full length. The gas and air feeds were each separately controlled by sliding valves. There were 12 of these in the combustion chamber, which was situated rather more than half way in the length of the furnace. There were three zones—preheating, soaking, and cooling—and although they were not isolated, the conditions were accurately controlled for each of these stages. The combustion chamber comprised the roof of the soaking zone, part of which was constructed at an angle of 45 deg. The burning gases impinged on this portion and the heat was reflected by radiation evenly throughout the zone. The waste gases traversed the preheating zone, giving up their heat to the incoming bombs.

The ends of the bombs were plugged with special bricks to prevent internal oxidation, and were placed on pallets of heat-resisting cast iron which were pushed in the channels through the furnace by hydraulic ram. The actual operation consisted of lowering the bombs from a pendulum conveyor on to the pallets which had been placed previously on carriages on an endless-chain conveyor running the full width of the front of the furnace. They were spaced to take up positions

# MANUFACTURE OF CAST-STEEL BOMB BODIES.

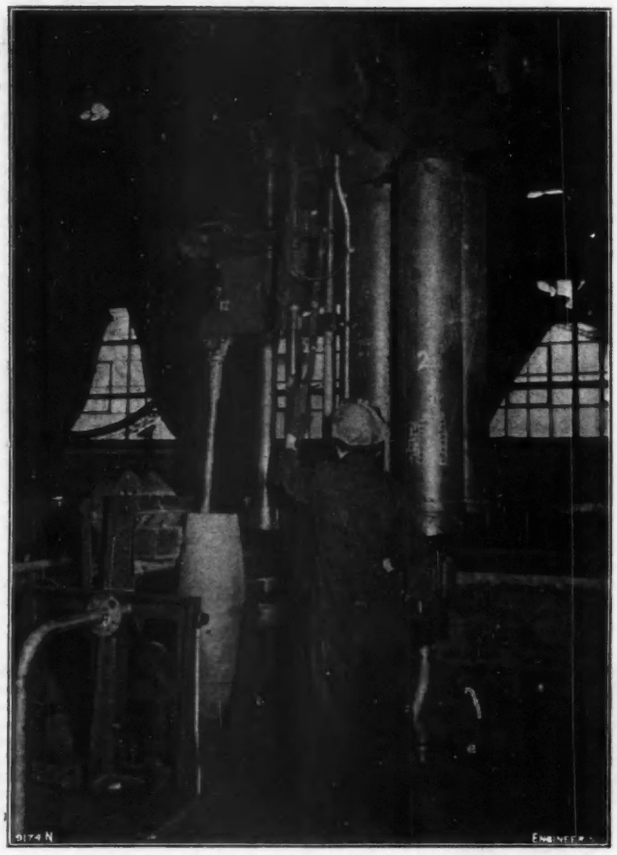

FIG. 13. ENTRANCE TO "WHEELABRATOR" CABINET.

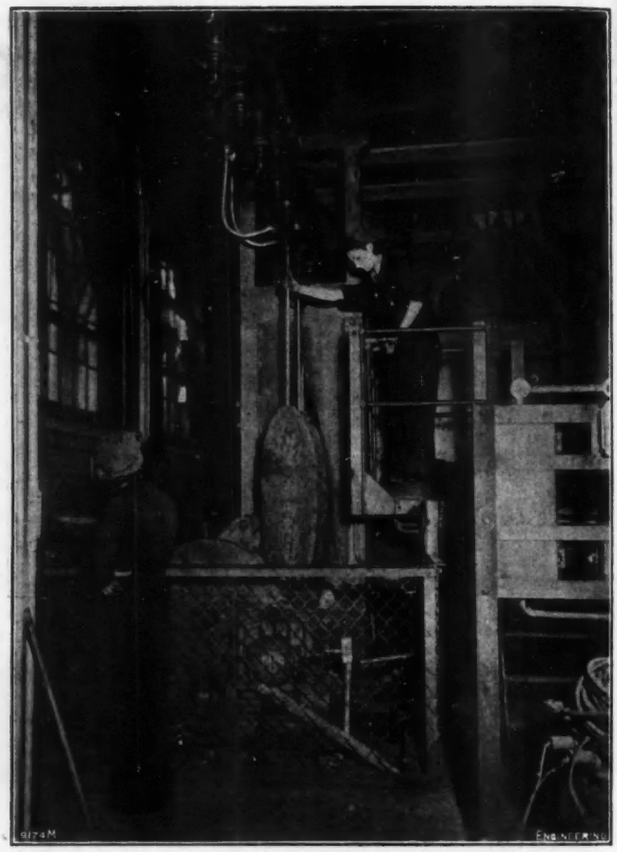

FIG. 14. VERTICAL INTERNAL-GRINDING MACHINE.

opposite the longitudinal channels, and a six-pronged ram then pushed the row into the furnace and at the same time pushed out six fully treated bombs at the other end. The bombs thus travelled through the furnace in single rows with adequate space all round. There were 74 rows, each of six bombs in the furnace at all times, 17 rows of which were in the soaking zone.

The rate at which the castings passed through the furnace was controlled by the frequency of charging and by the length of each push, i.e., the length of the pallet. The pallet was 15 in. long and seven pushes per hour resulted in 4½ hours for the bombs to reach the soaking zone, a further 2½ hours before leaving this zone, and exit from the furnace in a further 5½ hours. The temperature in the soaking zone was measured at eight different points and never varied by more than 20 deg. C. between any two points. Outside the furnace, the bombs were handled throughout by pendulum hooks on an overhead chain conveyor, which served both furnaces. This conveyor was brought down to a lower level at the inlet and exit ends of the furnaces, and was arranged so as to deliver the heat-treated bombs to the next operation, i.e., internal grinding. The furnaces were fired by raw producer gas from an existing battery of ten producers of special design. The steam for the producers was generated in a boiler operated by waste heat from the heat-treatment furnaces. The fuel used was washed nuts.

The final operations prior to machining were shot blasting and internal grinding. The pendulum conveyor serving the annealing furnaces also carried the bombs forward to the grinding shop. They were first deposited at one of four Wheelabrator cabinets, shown in Fig. 13, on this page, and passed through, suspended tail down from an endless chain conveyor. They were hung on at fixed centres with a rod 4 ft. long which had been threaded previously through the nose end bore. The bombs were rotated inside the cabinet by means of sprockets at the top of each hook. A turnover thruster operated at the entrance and exit ends of each cabinet. These were worked by an automatic electric switch operated by the entry of the bomb, and a compressed-air ram worked in conjunction with each turnover thruster.

The bombs were shot-blasted with Grade C steel shot from three impellor wheels, each 16 in. diameter, one working at the side, and two on the floor of the cabinet. They worked at a speed of 2,000 r.p.m. and each projected 300 lb. of shot per minute. The bombs were thoroughly cleaned inside and outside by this treatment. The cabinet was lined with chilled cast-iron plates of special composition, 1 in. in thickness, for protection, particularly opposite the impeller wheels, where rapid wear would otherwise have taken place. Ten cwt. of shot were needed to start up each Wheelabrator, and to compensate for broken down shot, 1 cwt. was added every two hours. The machine was stopped after four hours' running for general inspection, which occupied approximately 15 minutes.

The bombs were rolled horizontally on gantries from the Wheelabrators to internal-grinding machines, shown in Fig. 14. The 16 machines for carrying out this operation were designed by Stanton and worked very successfully. The holder for the bomb consisted of four rubber-covered rollers, one driving and three idle, fixed at the required points and set in two brackets. The brackets were fitted to the machine table, which was set at an angle to allow a maximum swing of 90 deg. from the horizontal. A bracket clamp, counter-weighted with an idler roller, was fitted to the foot of the table and a swivel was mounted in ball bearings to support the bomb nose end to allow free rotation.

The bomb was placed in the cradle and kept in contact with the driving roller through the clamp pressure. The table was moved to the vertical position and the body-grinding unit lowered into the tail-end bore. The bomb was rotated at 29·5 r.p.m. by a geared motor and the grinding head running at high speed was inserted. The unit travelled down the bomb wall and a reversing switch came into operation at the required depth. Grinding was continued during the traverse of the head on its return. A second high-speed grinding unit, which was part of the same machine, was used for nose-end grinding. The time per bomb, in and out of the machine, was eight minutes. The bombs were finally lowered by 5-cwt. electric hoists running on a monorail, on to a conveyor, and proceeded to the bonded store, where storage space was provided for the output of approximately three shifts (3,000 bombs).

There was a special routine of laboratory control for the foundry, as it is obvious that any drastic departure from established technique at the high production rate, could cause not only serious dislocation in certain sections, but also result in wasteful use of supplies. Samples of all raw materials were regularly tested, and control was also applied to the sand system. Samples of moulding and core sand were taken every hour at mills, sandslingers and core machines, and full tests were carried out. The build-up of clay or silt was guarded against by daily tests on the returned and reconditioned sand, and the efficiency of the desilters was checked by tests on the material removed by the cyclone fans. In view of the magnitude of the undertaking and the class of labour available, it was obvious that some departures from conventional methods of steel-casting production were unavoidable. Many of the major operations dealt with in the paper can be described as innovations. That they were highly successful is shown by the fact that this particular foundry, using 50 per cent. female labour, produced 880,000 500-lb. bomb bodies in the four years of its operation.

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L.N.E.R. ELECTRIC LOCOMOTIVE IN HOLLAND.—Work on the Manchester-Sheffield electrification scheme of the London and North Eastern Railway was suspended during the war, but has recently been resumed. The first electric locomotive for this service was completed in 1941; it is a mixed-traffic type developing 1,850 h.p. By arrangement with the Netherlands Railways, this locomotive was shipped to Holland in September for trials, to gain operating experience which will be of value in the construction of the remaining 84 engines required for the Manchester-Sheffield line. The locomotive has recently completed 10,000 miles running in Holland, and no defect has occurred. It has been hauling passenger trains weighing 330 tons, and the maximum permitted speed of 65 m.p.h. has been reached in five minutes. Freight trains weighing 1,600 tons have also been hauled, and a speed of 40 m.p.h. has been reached in five minutes.